

Tales of the Iron Bloomery

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Tales of the Iron Bloomery

*Ironmaking in Southeastern Norway—Foundation of
Statehood c. AD 700–1300*

By

Bernt Rundberget

Translated by

John Hines



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Contents

Preface IX

List of Figures and Tables XI

1 Introduction 1

Area and Boundaries 3

Chronological Depth 8

The Evidence 10

Topics and Aims 12

Key Issues 14

Outlying Land and Its Use 16

Regions and Technological Boundaries 20

Exploiting the Landscape 23

The Economic Context of *Jernvinna*—Domestic Activity, Craft or
Something More? 29

2 Research Backdrop 42

Status of Research 42

The Introduction of Iron and *Jernvinna* 44

Methods of Production in Chronological Terms 45

The Slag Tapping Furnace in Europe and Scandinavia 48

Charcoal Burning, Spatially and Temporally 69

Bog Ore and Roasting Places 76

3 *Jernvinna* in the Gråfjell Area—Conformity in Distinctiveness 80

Introduction 80

Rolf Falck-Muus—A Major Contributor 80

Recent Surveys and Excavations 86

Bloomery Ironmaking in the Gråfjell Area—Form and Facts 88

The Archaeological Investigations 98

The Slag Tapping Furnace of the Gråfjell Area—A Distinct
Method 118

Unexcavated Bloomery Sites 129

From Concept to Symmetrical Organization 132

Bloomery Sheds 138

Occupation or Settlement? 142

Rødsmoen and the Gråfjell Area Compared 146

	Charcoal Pits—From Statistical Bulk Sample to Organizational Factor	148
	Roasting Places—A Factor in a Comprehensive Understanding	161
	Organization and Exploitation of Resources	175
4	A Regional Tradition	183
	The Source Material	183
	South Østerdalen	184
	Solør	196
	Hedemarken	204
	The Delimitation of the Hedmark Tradition	208
5	The Dating of the Hedmark Tradition	216
	Introduction	216
	The Bayesian Approach	219
	The Summing of Radiocarbon Dates	222
	Wood Species and the Dating of the Hedmark Tradition	222
	Wood Species Determinations	223
	Annual Growth Ring Counts and Dendrochronology	227
	The Bayesian Approach—Precise Dating of the Period of Use	230
	The Gråfjell Area—a Specific Chronology	240
	14C Dates at Rødsmoen	242
	The Dating of <i>jernvinna</i> in Hedmark	243
6	The Volume of Production from the Hedmark Tradition	249
	Calculations of the Volume of Slag Heaps	249
	Calculations of Volume of Slag	252
	Calculations of Yield	253
	The Volume of Charcoal Production	255
	The Volume of Iron Production	257
	The Consumption of Raw Materials and Yield	266
	Volume and Period of Use	269
	The Volume of Iron from the Hedmark Tradition	271
	The Volume of Production through Time	273
7	The Study Area in the Light of Archaeological and Historical Sources	276
	Settlement and Its Development	276
	Hunting	292
	The Written Sources	296

8 Tales of the Iron Bloomery	319
The Technological Concept and Coordinated Activity	319
Methods in the Borderland	321
The Hedmark Tradition in Time and Space	336
Specialized Work	342
Proto-industrialized Bloomery Ironmaking—the Unknown Economy of Østerdalen	346
De-industrialization—the Collapse of the Tradition	351
9 The Economic Role of Iron in an Inter-regional Perspective	361
Appendices	368
Appendix 1a: Bloomery sites excavated in the Gråfjell area — data and interpretation	368
Appendix 1b: Excluded bloomery sites, not archaeologically investigated	378
Appendix 11a: 14C-datings and dendrochronological datings from the Gråfjell area	387
Appendix 11b: Excavated and dated bloomery sites of the Hedmark tradition	405
Appendix 11c: Excavated and dated charcoal pits of the Hedmark tradition	414
Appendix 111: Calculation of volume and estimation of weight of slag in slag heaps	426
Bibliography	443
Primary Sources	443
Secondary Sources	443
Internet Sources	473
Index	474

Preface

Tales of the Iron Bloomery is a significantly revised and modified version of my Ph.D dissertation 'Jernets dunkle dimensjon. Jernvinna i sørlige Hedmark sentral økonomisk faktor og premiss for samfunnsutvikling c. AD 700–1300' (2013), facilitated for international readers.

The book is a result of many years of research on the *jernvinna* in the south-eastern part of Norway. In 2003, I became engaged in the Gråfjell Project to lead the excavations of the archaeological monuments related to ironmaking. The project originates in the establishment of a new shooting range for the Norwegian Armed Forces near Rena. Prior to this, a large-scale archaeological rescue project was carried out. The Gråfjell Project is the largest archaeological project undertaken in the outlying land in Norway, covering an area of almost 200 square kilometres. Archaeological survey of the area identified a large quantity and range of sites and monuments. However, sites related to bloomery ironmaking were in the majority, mainly related to what must have been a highly intensive iron extraction period, c. AD 975–1290. The material gave opportunities for studies on such objects as technology, time, scale, resource utilization, distribution and landscape use. The results as they are presented here would not have been nearly so good without being surrounded by the excellent project group; Kathrine Stene, Tina Amundsen, and David Hill, as well as a dedicated field managing staff; Siv Anita Lundø Vikshåland, Hege Damlien, Ragnar Bjørnstad and Per Ditlef Fredriksen

As an extension of the excavation project, I was granted three years of funding from the Museum of Cultural History (MCH), University of Oslo. The grant has to be seen in the context of the museum's political strategy to develop Cultural Heritage Management excavations into research projects and new knowledge. I am grateful that the MCH gave me this opportunity to continue working with this exceptional material.

The aim of the research has been to use the collected archaeological data from the rescue excavation in a broader context. The study area was expanded to cover large parts of Hedmark County as well as the westernmost parts of Värmland, Sweden. In addition, adjoining areas were analyzed for technological comparison. Central in the research was to establish the cause and impetus for the regionally defined bloomery ironmaking process in Hedmark. Questions about origin and organization lead to the main objective—to use the archaeological material to discuss the importance of iron to the Viking Age and medieval society.

To this end, I have received a good deal of help, comments, advice and input from a number of colleagues and scholars: Kjetil Skare, Ove Terje Holseng, Ole Risbøl, Jostein Bergstøl, Lil Gustafson, Axel Mjærum, Ingar Gundersen, Birgitta Berglund, Raymond Sauvage, Ragnhild Berge, Lars Stenvik Øystein Vaagan, Ola Klefsås, Tom Haraldsen, Lars Erik Narmo, Arne Espelund, Per Olav Mathisen, Ole Tveiten, Randi Barndon, Gitte Hansen, Per Kristenstuen, Unn Pedersen, Kjetil Loftsgarden, Jón Viðar Sigurðsson and Per Persson. I have received great help with access to and interpretation of the Swedish material from Lena Grandin, Eva Hjærtner-Holdar, Svante Forenius, Gert Magnusson, Egil Aas, Lars-Erik Englund, Eva Myrdal, and Eva Svensson. From Denmark, I got great support from Olfert Voss, Arne Jouttijärvi, Jens Jørgen Olesen and Henriette Lyngstrøm. Thanks to you all. Eva Svensson and Henriette Lyngstrøm were also examiners of my PhD dissertation. I am thankful for their comments and views, which have been important in the processing of this manuscript. A special gratitude goes also to my supervisors Christopher Prescott and Jan Henning Larsen for great encouragement and support during the work with the doctoral thesis.

Warm thanks go to all of you that have given me permission to use, and helped me find figures and photos for this book. Thanks also to Magne Samdal who has been very helpful with producing the maps.

I am grateful to John Hines, not only for translation, but also for commenting on the manuscript during his work and I also want to thank Marianne Noble for her great and thorough copy-editing of the manuscript. At Brill, I am very grateful to Marcella Mulder, who has been a great coordinator in the work producing this book, in all its stages.

Thanks also to the following institutions which made it economically possible to finalize this book: The Research Council of Norway, Faculty of Humanities and MCH at the University of Oslo and the NTNU University Museum in Trondheim.

Last but not least, I want to thank my wife, Ann Kathrin, for comments and discussions, but specially for her patience and keeping track of home and our children Isrid, Tias and Estin in periods when dad was away.

List of Figures and Tables

Figures

In the case of maps, unless otherwise stated, the base map is from the national cartographic service (*Statens kartverk*), permission number NE12000-150408SAS.

- 1.1 The study area in southern and central Hedmark 5
- 1.2 *Regionfelt Østlandet*/the Gråfjell area in Åmot County showing all recorded ancient monuments 7
- 2.1 Recorded bloomery sites and charcoal pits in southern and central Norway, following Askeladden, 1 May 2012 43
- 2.2 Typological scheme of known varieties of shaft furnaces with a slag pit 46
- 2.3 Tapping slag in the form of a fan from roman slag tapping furnaces at Ferrum Noricum, Hüttenberg, Austria 49
- 2.4 Reconstruction of a double furnace excavated at Hedenstorp in Axamo, Småland 55
- 2.5 Places mentioned in the text 57
- 2.6 Reconstruction drawing of iron production furnaces at Hovden: schematic drawing of a furnace with slag channel, based on one of the furnaces at Godstøylbekken 62
- 2.7 Slag tapping shaft furnace at DR 36 in Dokkfloy, Gausdal Vestfjell, Oppland 64
- 2.8 The isolation pit beneath the smelting furnace excavated at Hallbekken, Skotterud in Eidskog 65
- 2.9 Interpretation of a slag tapping shaft furnace at Rødsmoen 66
- 2.10 Charcoal pit drawn by V. Biringuccio (1540 [2005]) 71
- 2.11 Sketch drawing of a roasting fire, after O. Evenstad (1782 [1960]) 1 77
- 3.1 Falck-Muus's map of bloomery sites from records and his own surveys 81
- 3.2 Excavated furnace hearth (isolation pit?) at Tyskeberget in Åsnes 82
- 3.3 Typological classification of bloomery sites at Rødsmoen 89
- 3.4 Recorded bloomery sites and charcoal pits in the Gråfjell area 91
- 3.5 Overview of the most common components of ironmaking sites in the Gråfjell area 94
- 3.6 Tapping cone 23 cm high. Left: the surface has the form of set molten wax because the slag has been tapped out and set in the cold air. Right: the back was in contact with the shaft wall which has partly melted into the slag 96
- 3.7 Tapping slag that has run down between the stones in the pit wall and set against the staves, which have left clear imprints 97

- 3.8 Upper: a nearly complete base slag with the shape of the circular furnace wall. At the top, the impression of the staves can be discerned, and at the very top of the picture is the imprint of the furnace mouth. Below: the underside with the impression of the staves in the lining 99
- 3.9 Bloomery sites and charcoal pits investigated in the Gråfjell area 100
- 3.10 Jfp.3: plan of production site 1 101
- 3.11 Jfp.3: furnace 2 at production site 1 104
- 3.12 Jfp.3: left, plan of production site 2 105
- 3.13 Jfp.16: plan of the ironmaking site 108
- 3.14 Jfp.20: plan of the ironmaking site 113
- 3.15 Jfp.20: furnace 1. Isolation pit viewed from directly above. In the left-hand pit edge are clear impressions of staves in the slag 114
- 3.16 Jfp.20: remnants of a building with corner stones and fireplaces 116
- 3.17 Slag hook for cleaning furnace walls, tuyères and tapping holes 117
- 3.18 A large fragment of a clay shaft found at Jfp.2 119
- 3.19 Section through the isolation pit belonging to furnace 2 of Jfp.3 122
- 3.20 Excavated isolation pits showing construction of the pit stonewall, the wood lining inside and tapping direction 123
- 3.21 Jfp.28: the isolation pit belonging to furnace 2 has been excavated 124
- 3.22 Tuyère (C52708/1) found in a slag heap at Jfp.39 127
- 3.23 Artefacts found at Jfp.23 128
- 3.24 Part of the Hylestad doorway from Valle in Aust-Agder. Here, Regin is forging a sword for Sigurd Fáfnir's-slayer, for the battle with the serpent Fáfnir. An assistant is working the bellows 129
- 3.25 The furnace drawn from cross-section measurements and according to interpretation of morphology and activity 130
- 3.26 Schematic representation of the most important components of a phase of use at the ironmaking sites of the Gråfjell area (not to scale) 133
- 3.27 Iron picks found at ironmaking sites Jfp.11 9C53983/1) and Jfp.39 (C52708/1) 138
- 3.28 Schematic representation of the organization of excavated ironmaking sites. All are interpreted as being based upon the basic model 139
- 3.29 The bloomery shed at R695, Rødsmoen, deduced from topography, post holes, layers and stones 140
- 3.30 Plan of building at Jfp.28. See 3.33 for a suggested reconstruction 143
- 3.31 Whetstones found at bloomery sites in the Gråfjell area. From left, Jfp.5 (C53377/6), Jfp.14 (C53392/5), Jfp.28 (C54395/1), Jfp.30 (C54390/2) and Jfp.32 (C54349/6) 144
- 3.32 Aerial photograph and section drawing of charcoal pit/pit building at Jfp.10. The photograph shows the square stone setting, the cut and the scorched stone

- clearly. The section drawing shows the structure of the charcoal pit and the building 146
- 3.33 Interpretation of ironmaking site Jfp.28 on the basis of the layers and structures excavated 148
- 3.34 Section through charcoal pits Jfp.10–3 and Jfp.10–4. In the section, typical stratigraphic sequences can be made out quite easily 152
- 3.35 Section of charcoal pit Jfp.29–7 showing two activity phases 153
- 3.36 Section drawing of Jfp.1–2 154
- 3.37 Charcoal pit Jfp.29–7 with two clearly separate phases of use. The base of the kiln of the second phase is slightly off-line in relation to the original one 155
- 3.38 At one side of charcoal pit Jfp.9–12, several preserved layers of logs were found 155
- 3.39 Charcoal pit Jfp.30–2. The base of the kiln. Bottom right, the photos show a black spot (arrow) in front of the survey pole which represents an impression left by a small firing post that was placed in the middle of the pit 156
- 3.40 The two emptied charcoal pits Jfp.11–6 and Jfp.29–3. Above, charcoal pit Jfp.11–6. Below, charcoal pit Jfp.29–3 158
- 3.41 Plan and section of charcoal pit Jfp.29–3 with the number of widths and heights of logs 158
- 3.42 Interpretation of the timber construction based on the charcoal pit Jfp.11–6 159
- 3.43 Tatyana Smekalova making a detailed plan of roasting site Rp.24. The yellow flags mark anomalies identified by free-searching. Blue-coloured pins mark the centre of the roasting site 163
- 3.44 Mapping by magnetometry. The recorded roasting sites lie close together in slightly sloping terrain between Merramyre/Tørråskjølén and Malmmyra. No roasting sites were identified around bloomery sites Jfp.2, Jfp.3, Jfp.5 or Jfp.8 165
- 3.45 Roasting sites recorded in the Gråfjell area. The roasting sites lie close to hillslope bogs in gently sloping terrain 166
- 3.46 Roasting sites in Vestre Jernskallia between Malmmyra and Eldmyrene 167
- 3.47 Roasting site Rp.22 identified on a spruce-covered 'island' in a grass-covered hillslope bog between Eldmyrene and Malmmyra 168
- 3.48 Rp.16, fireplace 2 after cleaning. The roasting site was nearly square 168
- 3.49 Rp.18 before deturfing. The roasting site is in thick spruce woodland, which is typical of areas where the conditions for ore-formation are good 169
- 3.50 Rp.18 in profile. The photograph to the right was taken using a flash and emphasizes the stratigraphy 170
- 3.51 Map of all the recorded bloomeries, charcoal pits and roasting sites in the Gråfjell area. The map is based on the surveys undertaken by NIKU and Smekalovs 176

- 3.52 Typically flat pine moor landscape with low morainic ridges in the south of the firing range 177
- 3.53 The forest gets denser in the north, with spruce taking over and dominating the vegetation 177
- 4.1 The distribution of bloomery sites in Rendalen (after Askeladden) with sites referred to 186
- 4.2 The distribution of bloomery sites in Stor-Elvdal (after Askeladden) with sites of the Viking Period and Middle Ages referred to 188
- 4.3 The distribution of bloomery sites in Trysil (after Askeladden) with sites referred to, also including the surveys of Falck-Muus (1927) and Lunde (1977) 190
- 4.4 Ironmaking site id 39958 near Brunhøgda in Trysil. The site consisted of two slag heaps of which that to the north (pictured) was large and clear 192
- 4.5 The distribution of bloomery sites in Åmot (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931) 193
- 4.6 The distribution of bloomery sites in Elverum (after Askeladden) with sites referred to, also including the surveys of Falck-Muus (1931) and Lunde (1977) 195
- 4.7 The distribution of bloomery sites in Våler (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931) 197
- 4.8 Sectioned slag heap at bloomery site id 121321. The remains of two slag heaps, which made up a standard model, were identified. The heaps contained tapping slag, the remains of base slags, and slag with wood impressions. This shows that the furnaces had isolation pits beneath them 199
- 4.9 The distribution of bloomery sites in Åsnes and Grue (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931) 200
- 4.10 Slag heap at bloomery site id 78190. The slag heap has been sited on slightly sloping ground down by an ore-rich bog. The production zone is situated above the heap, and the test pit was placed in the slag heap facing the furnace zone 203
- 4.11 The distribution of bloomery sites in Kongsvinger and Eidskog (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931) 205
- 4.12 The distribution of bloomery sites in Løten, Hamar and Ringsaker 207
- 4.13 The distribution of bloomery sites in Värmland (after Fornsö) 211
- 4.14 Extract from Fornsök showing the distribution and organization of iron extraction in the north of Torsby, east of Åsnes-Finnskog 213
- 4.15 The extent of the Hedmark tradition, with borders marked. Charcoal pits are also shown on the map 215
- 5.1 The distribution of calibrated dates presented in 25-year intervals across the period 1200–550 BP and with ranges of ± 25 BP and ± 75 BP (opposite side) 217

- 5.2 Relationship between growth rings counted and dating from the dendrochronological studies 230
- 5.3 Samples that have been both dendrochronologically and radiocarbon dated. The earliest date of felling is included in the calibration diagrams 231
- 5.4 Summary of the dates at bloomery Jfp.3 233
- 5.5 The result of the MCMC analysis of Jfp.3 presented in a multiple plot. On the right, it is assumed that there has been a break in the work (overlapping) and on the left that there was uninterrupted activity (continuous) 235
- 5.6 Modelled dates from Jfp.16. It is clear that considering the dates together and undertaking a statistical calculation of probability reveals it to be most likely that the activity took place sometime between AD 1150 and 1240 237
- 5.7 Modelled dates from Jfp.20, including the absolute dendro-date from furnace 2. It can be seen that this affects the relative dates of the charcoal 238
- 5.8 Modelled dates from Jfp.20, not including the dendro-date from furnace 2. This makes the starting point of the activity earlier and introduces greater uncertainty 239
- 5.9 Calibrated and modelled interpretations of the periods of use of bloomery sites in the Gråfjell area. Only sites with more than three dates have been included 240
- 5.10 Modelling of the start and end of *jernvinna* in the Gråfjell area 243
- 5.11 Modelled views of the start and end of ironmaking activity associated with the Hedmark tradition and at Rødsmoen 244
- 5.12 Calculation of the start and end points in Region_West assuming a uniform distribution of the dating evidence (Boundary) 245
- 5.13 The start and end point for the six regions defined. The picture shows unambiguously that production began in the southern and eastern areas before spreading out gradually to the north and west 247
- 6.1 The excavation of a slag heap at Jfp.32. The heap measured 7.8×4.6 m and was 0.9 m high 250
- 6.2 Left: the formula for a half-ellipsoid is $(4/3\pi \times ABC)/2$, where A, B and C are the radius of length, height and width respectively. Right: sections through an oval and a pointed slag heap. Grey shows the maximum difference (36.3%) 251
- 6.3 Modelled date ranges with start and end dates for activity at Jfp.17, Jfp.30 and Jfp.31 270
- 6.4 Iron extraction through time in the Gråfjell area on the basis of 28 bloomery sites. The period of use of the individual sites is calculated in 5.13 and 5.5 273
- 6.5 The calibration curve IntCalog for the period AD 600–1400 (Reimer et al., 2009). The period AD 1050–1150 is difficult to date, and even small differences move the dates forward in time 275

- 7.1 Settlement in Åmot in the High Middle Ages. Open square = settled after the Black Death; black square = farm abandoned after the Black Death; ? = uncertain position; and () = modern farm-name 281
- 7.2 Burial mounds in Elverum, approximate distribution and quantity. The distribution shows the centre of activity of settlement in the Viking Period. Filled half circle = with finds, empty half circle = without finds, dots = stray finds 284
- 7.3 Settlement in Grue around AD 1050. Ring = farms from the Early Iron Age to the Viking Period; square = farms of the Viking Period 286
- 8.1 The chronological development of ironmaking regions in South-East Norway in the Viking Period and the Middle Ages 325
- 8.2 Chronological range of the start of the Hedmark tradition 341
- 8.3 Trade and exchange in iron, goods and services in Østerdalen and Solør in the Viking Period and earlier Middle Ages 347
- 9.1 A 19 kg iron bloom found beside a hollow way in the Gråfjell area 364
- 9.2 12 axe blanks strung on a spruce rod found at Granå in Jutland 365

Tables

- 3.1 Numbers of pre-reformation ancient monuments in the outlying land recorded by major projects in Hedmark since 1992 87
- 3.2 Excavated ironmaking sites according to the recorded type 90
- 3.3 Measurements and volume of slag heaps from production sites 1 and 2 at Jfp.3 102
- 3.4 The organization of ironmaking sites in Gråfjell based on the four components of furnace, charcoal and ore stockpiles, and slag heaps (see Fig. 3.28, cf. Appendices Ia–b) 135
- 3.5 Charcoal pits investigated in the Gråfjell area according to method 152
- 5.1 Overview of the radiocarbon dates obtained for the Hedmark tradition per county 224
- 5.2 Wood-species analyses undertaken during the ironmaking investigations in the Gråfjell area per year 226
- 5.3 Dendrochronological dates and felling dates for wood in charcoal pit Jfp.11-6 229
- 5.4 Datings of bloomery site Jfp.3 given as ages BP. The sequence has been determined on the basis of a *Prior belief*, directed by chronological and stratigraphical considerations 232
- 5.5 Iron production in the Gråfjell area in terms of sites active within 50-year periods 241

- 6.1 Measurements and calculations of volume of the slag heaps of R695, Jfp.30 and Jfp.1 252
- 6.2 Calculations of yield from six bloomery sites 254
- 6.3 A calculation using a 0.25 m³ from Jfp.11-6 demonstrates the relationship between *loose measure*, *fixed measure before-* and *fixed measure after removal* 256
- 6.4 Volume, yield and consumption of raw material at bloomery sites investigated. Specific yield values are given for sites where they have been calculated 258
- 6.5 Volume, yield and consumption of raw material at bloomery sites investigated. Specific yield values are given for sites where they have been calculated 262
- 6.6 Three ironmaking sites with calculated iron output and their associated charcoal pits with the calculated volume of production, together with the assumed need for charcoal and ore according to calculations of yield 268
- 8.1 Technological and organizational differences between the traditions of south-east Norway and the Hedmark tradition in the Viking Period and Middle Ages 323

Introduction

More than any other metal, iron has participated in the shaping of our world, and has left its mark on the history of the last two to three millennia. It decided victory or defeat. It overthrew cultures and built the kingdoms of the world. Iron was the material of the sword, but also of the plough; the lord of humankind, and our servant.¹

This quotation introduces the anniversary volume *Fra jernets saga*,² published in connection with the centenary of E.A. Smith in 1969. Much has been written and discussed concerning the role of iron in the development of society, both nationally and internationally, and in my view, the advertising manager of E.A. Smith, Herman Strøm Johansen, identifies several truly crucial events in this regard. The main point is the enormous significance iron as a *material* obtained when the knowledge of how to smelt the *raw material* of the ore to produce iron and steel was achieved. Subsequent working to produce dress-accessories, weapons, tools and structures is thus a consequence of the knowledge of how to transform raw material into a commodity. In this study, it is the sequence of production itself that is the principal focus. The further working of the finished product, normally referred to as ‘bloom’³ or split blooms⁴—i.e. whether or not hammering (‘shingling’) or initial consolidation was undertaken at the production site—is therefore not the issue. Norwegian blooms, their functions and differences, have been discussed in many contexts.⁵ However, evidence for the second part of the ironmaking, the refining process, is sparse. With a few exceptions, it is not excavated smithies that can be seen in connection to *jernvinna*. Nor are many smithies recorded near settlement or marked places. For this reason, it is difficult to directly say anything about

1 Johansen (1969) 35 [trans.].

2 ‘On the History of Iron’.

3 Norw. *jernlupp/blåsterjern*—Probably from the old Frankish *luppa* or *lopp*, meaning a shapeless mass. Also termed ‘sponge iron’.

4 Norw. *Fellujern*. Also termed ‘wrought iron’.

5 Olafsen (1916) 11; Heiberg (1923) 59–61; Hauge (1946) 144–158; Martens (1979a) 190–192; Stenvik (2006) 255.

relationships between these activities, e.g. to what extent they are executed together or separately by different groups.

Jernvinna is an old term in Norwegian, deriving from the Middle Ages. The first element, *jern*, means ‘iron’, and the second derives from the verb *vinne*, which is synonymous with *onne*, ‘to undertake seasonal farm work’. In other words, the word represents how iron production was often regarded as part of the annual cycle of work on the farm.⁶ It is probably the archaeologist A.W. Brøgger who brought the term into modern use.⁷ The metallurgist Arne Espelund⁸ suggests that this term was used in the Østerdalen valley to describe the Evenstad process as part of the recurrent activity of the farm. The term *jernutvinning*⁹ can therefore be treated as one stage in *jernvinna*, in a similar manner to making charcoal and roasting or torrefying the ore. In this book, the Norwegian term *jernvinna* is used untranslated to refer to the entire process, while the term ‘ironmaking’ refers to the actual production of iron.

Jernvinna is not to be regarded as the same as the more recent blast furnace production and modern ironworking. There is a fundamental difference in the raw material, as *jernvinna* in Norway was undertaken using bog ore. In ironworks, it is primarily rock ore that is used. Bog ore and sea ore have been used in Norwegian blast furnaces only in one case. This was at Øiensjøfoss ironworks in Trysil, Hedmark, where from 1831 to 1870 iron was produced using bog ore.¹⁰

The processes are different in that the more modern style of production in blast furnaces requires two stages. The ore is first melted in a blast furnace and the material *raw iron* separated from the waste. The high-temperature smelting process means that the raw iron has a high carbon content, which means in turn that it is brittle and not workable as cast iron. This requires an additional process, ‘refining’, in order to remove carbon from the molten cast iron through oxidation. In *jernvinna*, the latter process was unnecessary because the iron itself did not melt. The temperature is essential here. Pure iron melts at a temperature of about 1537°C. The temperature, as well as the ratio of charcoal to iron ore, must be carefully controlled to keep the iron from absorbing too much carbon and thus becoming unforgeable. Cast iron occurs when the iron melts and absorbs 2% to 4% carbon. The quantity of carbon in the mix

6 Bloch-Nakkerud (1987) 141–149; Jacobsen and Larsen (1992) 177; Loftsgarden (2007) 58–60; Larsen (2009) 5.

7 Hougen (1947); see Larsen (2009) 5.

8 Espelund (2005).

9 ‘bloomery ironmaking’.

10 Lillevold (1950) 208–217.

leads to variation in the melting point. A good workable iron has a content of up to 0.3% carbon, and the temperature has to exceed 1400°C for the iron to melt.¹¹ In a bloomery the temperature rarely exceeds 1250–1300°C. Central to the process is also the slag. This must be active: in other words, it absorbs oxygen and limits the absorption of carbon in the iron. When these factors are in play, the soft, workable iron takes on a sponge-like form, in contrast to the floating slag which has a lower melting point.¹² The slag is separated from the iron by being tapped off, down into a pit or out through tapping channels (see Ch. 2, Methods of production in chronological terms). The iron collects in clumps close to the mouth of the bloomery, and the piece can be taken out and worked straightaway. This method of production in *jernvinna* can therefore be referred to as the *direct method*—in contrast to the later, two-stage, *indirect* blast furnace technology.¹³ Ironmaking by the direct method is based upon relatively simple principles. The raw materials of ore and fuel, and air, are required. There must also be a structure in which the *reduction* can take place. This was almost entirely carried out in a clay shaft where, with either a natural or a forced draught (using bellows), it was possible to achieve the necessary temperature.

After this knowledge was gained and spread across large parts of the world, humanity and human cultures obtained a new commodity, and the material, as Johansen says, opened up new roads for the development of cultures, technology and construction. This book has this material as its subject matter—with technological development, economic impact and territorial control as the central topics of study.

Area and Boundaries

Jernvinna is known over large areas of Norway. In the north, production has been highly sporadic, and only three sites are known.¹⁴ In southern Norway the technology is found over wide areas, and production has been most intensive in Trøndelag and in the south-east. The exceptions are a strip of land along the coastal zones and areas above the tree-line of the time, where production would appear to have been very limited. A near absence of production in

11 Espelund (2005) 98–99.

12 See Tylecote (1976); Pleiner (2000); (1991) 49–62.

13 See Narmo (1996a); Espelund (2005).

14 Jørgensen (1999) 2.

low-lying areas is a natural consequence of the lack of suitable bog ore below the marine limit. The absence in the high mountains is equally self-explanatory, because of the lack of fuel. From the interior agricultural areas and up into the lower mountain regions, it is possible to identify ancient *jernvinna* at many sites. There is, however, both geographical and chronological variation. A more detailed discussion of position and distribution is found in Chapter 2. In what follows, only considerations that are fundamental to this study are presented.

The Geographical Area

The area of analysis is limited to the southern part of Hedmark County, which is in the eastern part of southern Norway (Fig. 1.1): from Eidskog Municipality in the south to Stor-Elvdal and Rendalen in the north, and approximately from the Swedish border in the east to Oppland and Akershus Counties in the west. This region is usually referred to as Østerdalen and Glåmdalen. Østerdalen is a historical name, derived from *Øystridalir*, 'the eastern valleys'. The old folk-boundary between the Opplanders and Trøndelag ran past Hanestad in Rendalen, a division reflected both in secular and ecclesiastical territories.¹⁵ On this basis, the region is divided into South Østerdalen (incorporating the municipalities of Elverum, Åmot, Stor-Elvdal, Engerdal and Trysil) and North Østerdalen (Rendalen, Alvdal, Folldal, Tynset, Tolga and Os). The boundary of the study area to the north more or less follows the boundary between North and South Østerdalen. The flatter area of the long valley from Våler Municipality southwards to the Swedish border and Akershus County is referred to as Glåmdalen. The principal districts in Glåmdalen are Solør and Odalen, of which the former is part of the study area.

Geographical and Topographical Conditions

The geography and topography of Hedmark is heavily influenced by the River Glomma, which flows through the valleys of Østerdalen and Glåmdalen. The size of the river and its connection to several tributary river systems mean that it can be regarded as the principal artery of this region. Mountains and an alpine landscape are less features of this long valley than they are of the comparable valleys in eastern Norway, and only the northern part could be counted as a mountain valley. Agriculture is dominant along the river itself, especially in Solør in the south, and many of the settlements in the county are found here. Agriculture is also dominant in the flat and fertile landscape of Hedemarken, which extends towards Lake Mjøsa. The landscape of Hedemarken should not be confused with Hedmark, which is the county where Hedemarken is located.

15 Andresen (2003) 97–98.

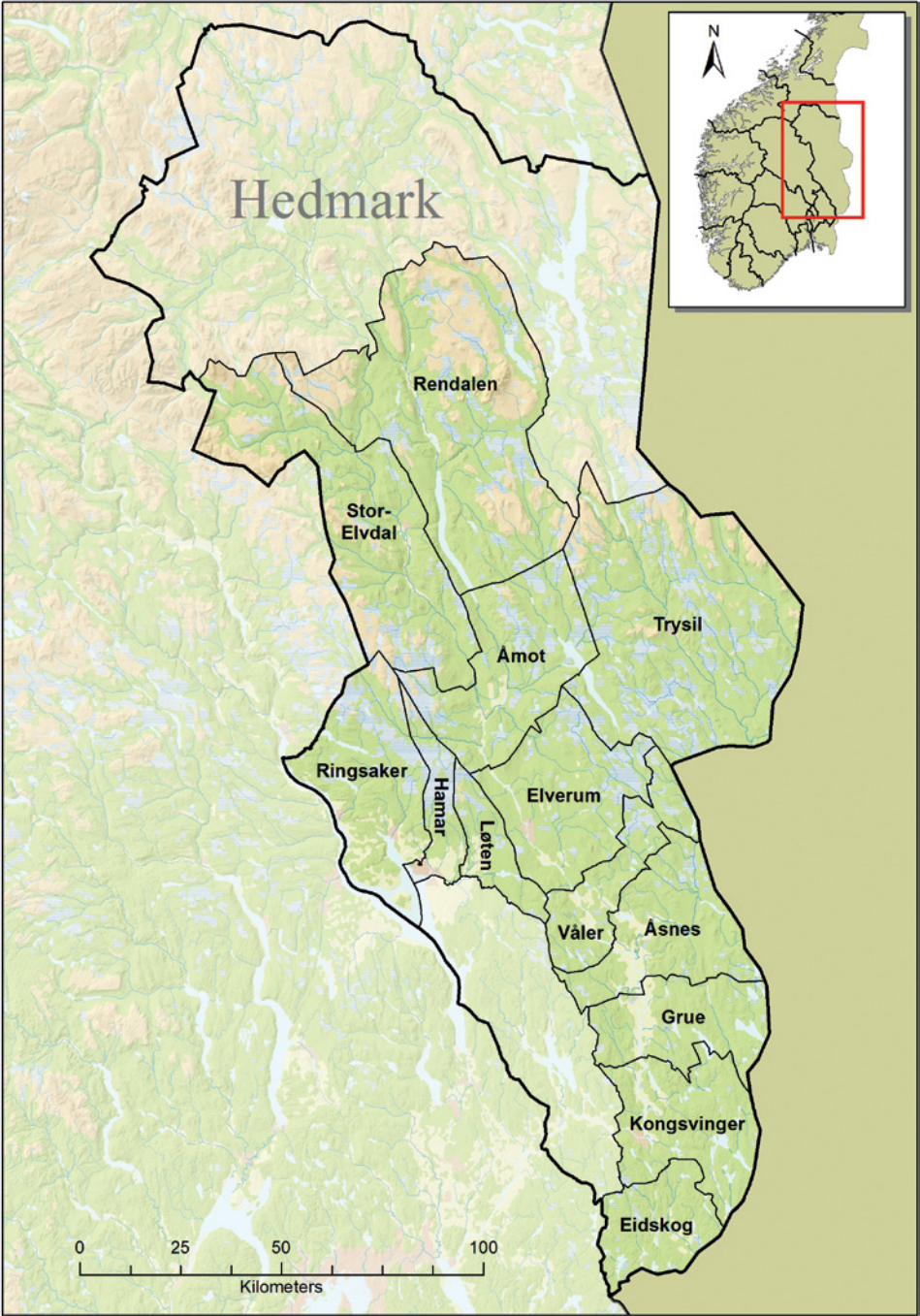


FIGURE 1.1 *The study area in southern and central Hedmark*
MAP: B. RUNDBERGET, MUSEUM OF CULTURAL HISTORY (MCH)

Towards the Swedish border, the landscape is characterized by conifer woodland, with the Taiga extending the whole way eastwards to the Pacific in Russia. In the north-east, the River Trysil flows into Sweden, where it becomes known as the River Klarälv. With its tributaries, this too has served as an important communication route. The greatest concentration of population is found in the agricultural areas and around Lake Mjøsa. In the woodland areas, the population is more dispersed, and large areas are more or less uninhabited.

Climate and Vegetation

The valleys of Østerdalen and Glåmdalen have a typical inland climate, with cold, snowy winters and relatively warm, but short, summers. The amount of rainfall creates an acidic soil layer and rapid bog formation, and is crucial for the maintenance of a rich, conifer-forest environment, and for the precipitation of iron oxides which are transformed into bog ore.¹⁶ The conifer woodland dominates almost entirely. The Eurasian Taiga begins between the cities Hamar and Elverum, runs to the Baltic and on through Finland and Russia across to the Pacific. The Taiga consists of conifers, mostly pine and spruce. The forest floor consists of heather and moss, with some birch and rowan, and here and there grassy glades. The pine forest is dominant on the sandy areas in the lower-lying areas, while spruce takes over in the higher, wetter and less even terrain. Up by the tree-line lies the birch zone. The vegetational map has not changed significantly since the Iron Age, despite fluctuations in temperature.¹⁷

Topography, Climate and Vegetation in the Gråfjell Area

The Gråfjell area, which is the core of the study area, is exactly the same as *Regionfelt Østlandet*, the new firing and training range for the Norwegian defence forces in Åmot district. This area is situated about 15 km north-east of the district centre in Rena and is physically bounded by three river valleys: the River Rena to the west, the River Søre Osa to the south and the River Slemma to the east. To the north, the area is bounded by the mountains around Gråfjell (Fig. 1.2).

The topography is varied, as the area is extensive, with a range in altitude of nearly 700 m from the lowest-lying areas in the south to the highest point, Gråfjell (1008 m ASL¹⁸) to the north. The landscape changes in character: In the south, it consists of the large, flat areas dominated by heath, boggy ridges and several small lakes. In the centre of the area there are uplands such as

16 Pettersson (1982) 35–68; Rueslåtten (1985) 31–38.

17 Høeg (1996) 54–55.

18 above sea-level.

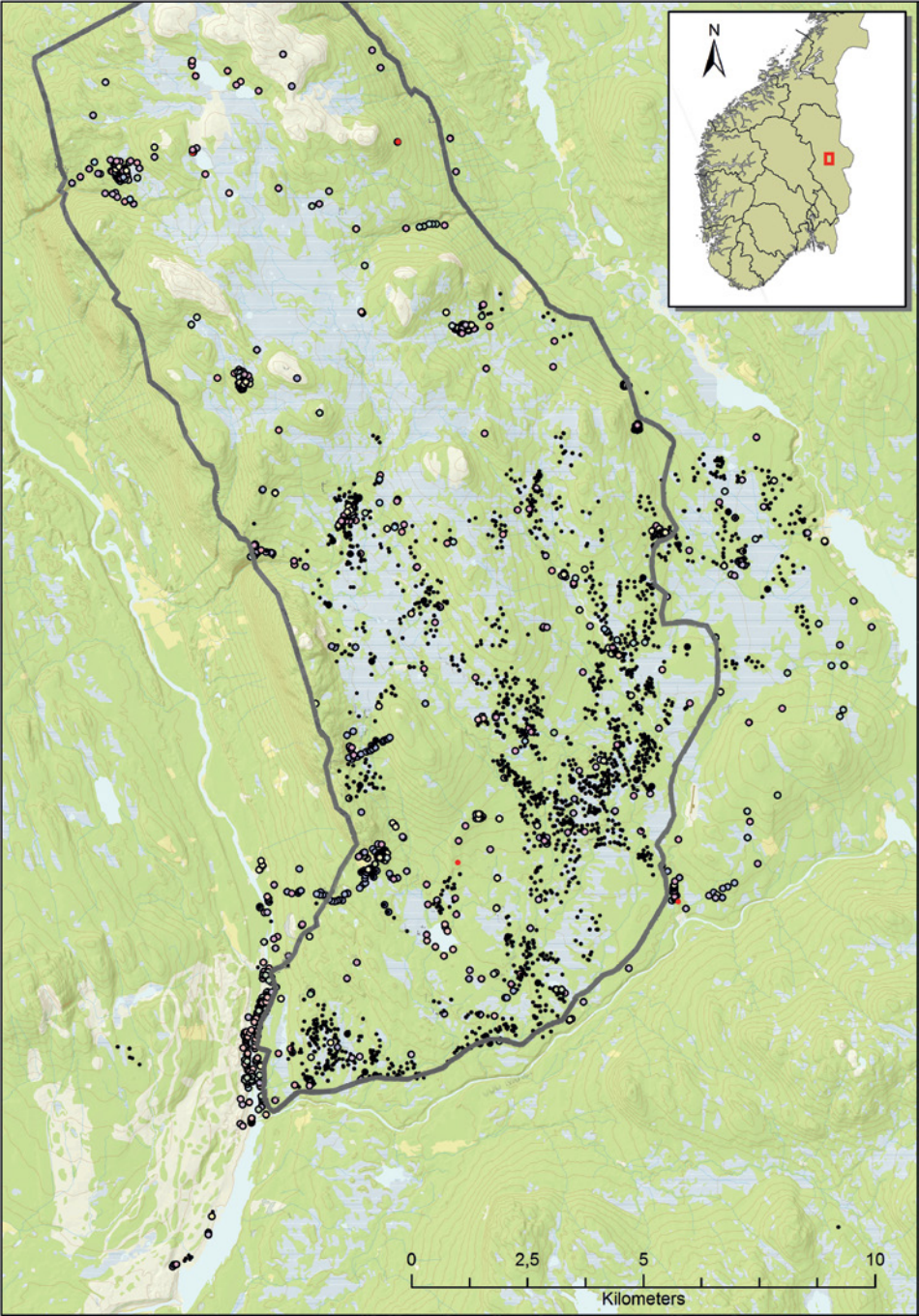


FIGURE 1.2 Regionfelt Østlandet/the Gråfjell area in Åmot County showing all recorded ancient monuments

MAP: B. RUNDBERGET/D. HILL, MCH

Jernskallen (751 m ASL) and Deifjellet (870 m ASL). To the north, the terrain increasingly turns into dense coniferous woodland, and into a stonier and more uneven ridged landscape. At the northern end, the landscape is characterized by large areas of bog, snow-covered mountains, sparse vegetation and alpine scrub.¹⁹

The climate in the Gråfjell area is like that of the rest of the area, but it has several botanical seasons. The distribution map of cultural remains shows that these zones governed the use of the area. In the south, the vegetation takes the form of flat pine heaths with heather and bog-growing undergrowth (Fig. 3.52). There are large boggy ridges between the pine heaths. Smaller areas of dense spruce woodland are also present. These are associated with characteristic mountainside bogs with wet ground. Moving north, the vegetation gradually changes character to consist of mixed and spruce woodland (Fig. 3.53). The undergrowth consists of a lot of scrub and long grass, and the terrain can be extremely wet and uneven, making movement difficult. To the far north, above the tree-line, the vegetation consists of heather, moss and thinly covered morainic deposits. As a resource for *jernvinna*, it is the southern zone that was primarily exploited, naturally enough as this area is rich in woodland. The highest ironmaking sites are found at around 700 m ASL. The tree-cover thins out above this altitude, and does not appear to have been usable.

Chronological Depth

In works on Nordic archaeology, it is important to be aware that the chronological scheme differs from those in more southern parts of Europe. Norway has no indigenous written sources except runic inscriptions from before the eleventh century, and 'historical times' therefore begin only at the transition from the Viking Period to the Scandinavian Middle Ages; the Middle Ages is considered to continue until AD 1537 (The Reformation).

The Iron Age is understood to run from around 500 BC up to and including the Viking Period. Before the Common Era/AD, the period is called the Pre-Roman Iron Age, corresponding to the La Tène. From AD 1 to around AD 400, we speak of the Roman Iron Age: this is divided into the Early Roman Iron Age, AD 1–200 (Eggers B1, B2 and C1), and the Late Roman Iron Age, AD 200–375/400 (Eggers C2, C3).²⁰ The Norwegian Migration Period covers the

¹⁹ Risbøl et al. (2002b) 8; Stene (2007) 9–15.

²⁰ Eggers (1955); Solberg (2000) 38, 72.

period AD 400–575 (Straume's D1 and D2)²¹ and closes the Early Iron Age. The Later Iron Age comprises what in Norway is called the Merovingian Period, AD 575–750/800, and the Viking Period, AD 750/800 to around AD 1000 (or 1030): this is the final period of Prehistory. The era of the Middle Ages covers the period AD 1000–1537; this is divided into Early, AD 1000–1130, High, AD 1130–1300, and Late phases, AD 1300–1537.

The chronology of *jernvinna* in Hedmark is relatively well attested, and I shall summarize it briefly. Iron production continued for a long period from the end of the pre-Roman Iron Age to early in the nineteenth century. The extraction and distribution of this iron largely followed wider cultural history. This can be seen in how, for instance, early iron production in eastern Norway is often located in association with those areas where we have evidence of early permanent and organized settlement.²² Most evidence of production in the Early Iron Age is closely linked to the fertile agricultural land at Hedemarken, and must be seen in connection with the farms and chieftainships in this area.²³

Iron production remained limited for a long time, and this is probably to be interpreted in terms of the immediate needs of the farms or settled districts. There is, in general, relatively little information on Early Iron Age production at Hedemarken as this period has only occasionally been studied. However, several structures in the flat settled districts on Hedemarken testify to significant iron production in the earliest centuries of the Christian Era.²⁴ In the eastern forest areas of Hedmark County there are fewer traces from the earliest period. In Elverum Municipality, several sites have been identified, while further north in Østerdalen there is a very limited distribution.²⁵ Three sites have been recorded in Åmot Municipality, and four are recorded in Stor-Elvdal Municipality. One must assume that the extent was somewhat greater, but what is recorded shows that *jernvinna* in the Early Iron Age was slight in comparison with other periods.

From the last phase of the Iron Age and well into the High Middle Ages c. 1250, *jernvinna* intensified and reached a peak. A smaller number of bloomeries dated to the sixth to ninth centuries have been recorded,²⁶ but it is not until the late tenth century that one can trace a clear and conspicuous increase,

21 Straume (1987); Solberg (2000) 128, 182–184.

22 Larsen (2004) 139–170; Larsen and Rundberget (2009) 38–50; Rundberget (2010).

23 Bårdseng (1998); Haraldsen and Larsen (2007); Rundberget (2010).

24 Bårdseng (1998).

25 Risbøl et al. (2002b); Rundberget (2007); Larsen (2009).

26 Narmo (1997) 22–34; Rundberget (2007) 154–160.

after which the extent of production rises quite steeply. In the course of a few decades, intensive iron production was established over much of southern Hedmark. In the middle of the twelfth century, output reached its peak, and this level appears to have been maintained until the middle of the thirteenth century.²⁷ Production then declined sharply and appears to have come to an end just after AD 1300.

The Evidence

The area of study is extensive, and the remains of iron bloomery sites are comprehensive. Within the limits of this project it has not been possible to undertake a complete and detailed analysis of all the cultural monuments registered. Consequently, certain areas have been selected for thorough examination. The basic material is taken from the Gråfjell area, where a lot of archaeological evidence has been recorded and excavated.²⁸ The immediate reason for this study was the government's decision to establish a regional firing and training area for sections of the defence forces in the Østland region, known as *Regionfelt Østlandet*.

The Norwegian Institute for Cultural Heritage Research (NIKU) surveyed the firing range and neighbouring areas. Four seasons of field survey were undertaken (1999–2002) within an area of about 200 km². The subsequent excavation programme (2003–2007) was organized by the Museum of Cultural History, University of Oslo.

A key collection of supplementary and reference material for this study is that from the excavations at the Rødsmoen site, south-west of the Gråfjell area. The Rødsmoen Project was also the result of military activity. It was the first major project in the outlying landscape in Hedmark County,²⁹ and therefore it created the framework for later surveys and investigations, including that in the Gråfjell area. Studies of *jernvinna* were at the heart of the project, and the results were published in a final report, as well as in one more popular scholarly book and in articles.³⁰

In addition, there are other, minor, studies and surveys that are used in these analyses. The evidence recorded from Hedmark is extensive. We may note the

27 Narmo (1997); Rundberget (2007), (2009) 72.

28 Risbøl et al. (2002b); Rundberget (2007); Amundsen (2007); Stene (2010), (2014).

29 Narmo (2000) with refs.

30 Narmo (1997), (1996b), (2003a) 61–66, (2005) 139–153.

‘Åker Project’,³¹ ‘Recording in outlying areas in Hedmark’,³² and surveys linked to the assessment of the impact of *Regionfelt Østlandet*.³³ This activity has resulted in more than 12,000 ancient monuments being recorded in the outlying parts of Hedmark. Monuments linked to *jernvinna* definitely account for more than half of these. In the study, this evidence will principally be used as reference material. Key details are the situation, form, type and size of the monument. The database of cultural monuments ‘Askeladden’,³⁴ together with inspections, literature and topographical archives, have been the fundamental sources of information.

A comparison with ironmaking in neighbouring areas is undertaken to a certain extent. Three areas for comparative studies stand out. In Oppland County, this is primarily through the Dokka Project,³⁵ supplemented with studies from excavation sites at Beitostølen³⁶ and Tyinkrysset.³⁷ Across the Swedish border, the regions of Dalarna and Värmland are of particular interest.³⁸ In northern Hedmark in this period there was more limited iron production,³⁹ while in the valleys of South Trøndelag County there was also iron production on a minor scale.⁴⁰ In this study, the principal objective of using this evidence is to discuss regional variations in technology and organization.

Further archaeological evidence is brought into the study, especially in discussion of the issues associated with the development of settlement, the exploitation of the outlying landscape, economic systems and territorial control. The evidence has been discussed in several contexts, and I base my own work on that scholarship.⁴¹

The archaeological evidence is supplemented by documentary sources that deal with the area under study. There are few historical documents which give any direct account of *jernvinna* in the Middle Ages, but both laws and decrees provide indirect information about the activity. Other relevant written sources

31 Pilø (1994); Bårdseng (1998).

32 Holm (1998).

33 Mangset, Roland and Skogstad (1996a), (1996b).

34 <https://askeladden.ra.no/askeladden>.

35 Larsen (1991); Narmo (1996a).

36 Mjærum (2007) 176–188.

37 Larsen, *Jernvinneundersøkelser*.

38 Serning (1973); Hyenstrand (1974); Pettersson (1982); Svensson (1998); Myrdal-Runebjer (1998).

39 Espelund (1997) 109–132; Nyeggen (2005).

40 E.g. Stenvik (1991a) 100–115; Sauvage (2005).

41 E.g. Fosvold (1936); Brøgger (1942) 16–26; Hveberg (1948); Lillevold (1950); Bergstøl (1997); Narmo (1997); Narmo (2000).

are charters, church registers and land registers. A further source that complements the archaeological and historical evidence is place-names. Place-name studies have been carried out in several parts of the study area, and the analyses will mainly be carried out on the basis of the results from the present research.⁴²

Topics and Aims

A number of topics can be examined in research on *jernvinna*, and I shall outline these briefly, in order to delimit my subject and objectives. Research on *jernvinna* in Norway has always been preoccupied with technical questions concerning process.⁴³ This is reflected in the results of some of the earliest researchers who specialized in this field.⁴⁴ In more recent times, it is the scientists Anna M. Rosenquist,⁴⁵ Sigmund Jakobsen⁴⁶ and particularly Espelund⁴⁷ who have remained closest to this tradition. Archaeologists entered the field relatively late, but the question then took on a more culture-historical character.⁴⁸ Economic and settlement questions were central. More humanistic and agent-oriented aspects, meanwhile, have remained largely unexplored, partly because of the difficulty of finding material to discuss, but also because of the exclusion of theoretical trends from the discussion.

In his doctoral thesis, the Swedish archaeologist Lars-Erik Englund⁴⁹ has identified a series of topics that can be studied in relation to *jernvinna*. These include everything from purely procedural/technical and material-technological issues at one extreme to more abstract questions at the other. In the middle lie topics which are indeed the most familiar ones, and on the whole are the most practical to examine in the context of the present understanding of *jernvinna* as an aspect of early society. This largely involves issues that have already been noted, such as settlement patterns and matters of social economics. In an earlier study, I emphasized that research into *jernvinna* has been too one-sidedly

42 E.g. Hveberg (1949) 5–29; Sørensen (1981) 55–87, (1999) 7–23; Harrson (1996); (2000); Nar-mo (2000); Østmo (2000) 9–63.

43 Rundberget (2002a).

44 E.g. Holme (1920) 41–57; Falck-Muus (1927) 358–397; Hauge (1946).

45 Rosenquist (1979) 37–49, (1988) 164–189.

46 Jakobsen (1983).

47 Espelund (1991), (2005).

48 Johansen (1973) 60–66; Martens (1988).

49 Englund (2002) 11–12.

directed at a few questions,⁵⁰ and that it has not followed the methodological and theoretical development of the discipline of archaeology as a whole. The defence has since been mounted that the highest priority has been to collect evidence and increase knowledge of the field, and that only when that has been done can one develop the range of questions to encompass a wider range.⁵¹ Nevertheless, I believe that it is important not to be too defensive in attitude in our studies of *jernvinna*. As I understand the archaeologists Lars Erik Narmo and Jan Henning Larsen, there is an either/or position that takes over when they find it difficult to analyse magic, rituals, taboo or symbols rather than continuing to place the stress on technology.⁵² By this, I mean that the issue has been misunderstood. Technology, as I have previously argued,⁵³ is more than a matter of methods and technical processes alone. Implicit within a technology are also political, economic and social elements (see. Ch. 1, Outlying land and its use). New questions are not intended to displace others, but rather to supplement areas of research that are already known. The critique is nonetheless justified to some extent, as it can happen that interpretations are taken rather too far in research. The archaeologist Unn Pedersen⁵⁴ considers this issue in the context of research on the Old Norse smith. Quite rightly, she sees that it is the mythologically portrayed ideal smith that has been the central focus in the new wave of study; not the real smith. She points out that it is important not to skip over the evidence that is indeed there, as in itself it bears significant witness to the nature and status of the smith. In this discussion, it is essential to stress what is crucial if we are to be able to link research into *jernvinna* to the disciplines of archaeology and cultural history more widely. This includes factors such as what we need to obtain information on in a continually changing society. In other words: how can the study of ancient *jernvinna* contribute to answering the questions with which our society is concerned at any given time?

A current issue in archaeology is the study of outlying land as a resource zone. The outlying landscape has been favoured with much attention in recent years, and the symbiosis between the outlying land, agrarian settlement and territorial control is crucial. Surveys and excavations in outlying areas provide information on the significance of the resources of this zone, both economically and socially, not only for agrarian but also for urban societies, in economic

50 Rundberget (2002a).

51 Narmo (2005).

52 Narmo (2005) 144; See Larsen (2009) 195.

53 Rundberget (2002a) 34–36.

54 Pedersen (2009) 134.

systems on different planes. The outlying land of Norway and northern Scandinavia is also in a unique state: there are enormous areas that remain more or less untouched, with very little development in these areas.⁵⁵ A paradox, then, is that the focus that is now directed at the outlying areas has much of its background in the recent growth of welfare amenities such as holiday-home complexes, mountaineering developments and anthropogenic climate change. The topic and objectives of this book are located in this issue, as *the principal aim is to use the archaeological evidence associated with jernvinna in Hedmark in the Viking Period and the Middle Ages to discuss the significance of iron for, and its economic role in, Viking Period and medieval society.*

Key Issues

Jernvinna in the Gråfjell area has been well mapped out by the Gråfjell Project, and in the excavation report I concluded that its extent implies that this business must have been economically fundamental for the population in the Late Iron Age and the Middle Ages.⁵⁶ This conclusion is based on the fact that the area stands out as having its own method of production, organization and chronological development, while in addition the scope of the enterprise was enormous. From here onwards, I choose to refer to this method of production as the *Hedmark tradition*, a term that was developed by Narmo⁵⁷ following the Rødsmo Project. On the basis of the *specific character, extent and chronology*, there are six key issues that stand out for investigation:

To Give an Account of the Technological and Organizational Features of Jernvinna in the Gråfjell Area

A first stage in the analysis will be to give an account of the technology involved, by presenting and discussing the results of excavation. Four aspects are picked out: *construction, process, organization at the bloomeries, and the organization of jernvinna within the landscape.*

Jernvinna in Hedmark as a Distinct Technological Tradition

Production in the Gråfjell area is not unique to this area alone; there is a similarity in the evidence from much of southern County of Hedmark. For this reason, I define *jernvinna* as a distinct, regional, technological tradition. The

55 Stenvik (1992) 24.

56 Rundberget (2007).

57 Narmo (2002) 140.

region is partly delimited by the absence of records, and incomplete descriptions mean that more reliable boundaries have to be derived from a defined typological similarity and distribution. The background to the development of this tradition is unknown. How and why such a regional development emerges is an essential basis for further discussion of the significance of *jernvinna* within a wider perspective.

The Organization of Jernvinna and the Exploitation of Resources

Understanding the organization of bloomery ironmaking is central to the task of interpretation. The archaeological remains bear witness to variation in the exploitation of resources. It is therefore necessary to proceed to question who was working in the ironmaking and who took part in the distribution of raw materials and products. An estimate of the numbers of agents in the production process will also provide some insight into the impact on the local context.

The Chronological Horizon of Jernvinna

The dating of production in the Gråfjell area has sharp chronological boundaries. A steady growth indicates that this style of production swiftly became established as a core economic factor. An even more rapid decline must, in its turn, have been of decisive significance for the population. It is crucial to see whether this picture holds over the whole region, and further what may have caused these rapid processes of change—but also to pose the question of whether the radiometric dates do give us an accurate view of the history of production.

Production as Part of an Economic System

It is clear that the level of production exceeded both local and regional needs, and that it had major wider effects. It is also obvious that the outlying land zone was a crucial resource for a marginal agrarian community. How its exploitation was actually practised is, however, little known, as historical and ethnological sources provide little information. It is thought-provoking, as a result, that the archaeological evidence which we have can be considered to undermine the assumption that farming and its self-sufficient agricultural economy was the foundation of the subsistence economy. The extent of iron production, by contrast, draws a picture of a complex and expansive economic system which stretched far beyond a self-sufficient farm economy.

A Controlled and Governed Activity

This form of production took shape immediately before or at the same time as the establishment of the national kingdom, and it collapsed some time before

the decline of the Norwegian kingdom gathered pace. One hypothesis, therefore, is that, initially, regional chieftains, and subsequently kings and the royal authority, were a crucial, if indirect, factor, and that the resources of the outlying land and especially the iron played a decisive role in the development of the kingdom. Just what the dynamics of this development were, however, is uncertain. The production must be regarded as having its roots in demand associated with urbanization, ecclesiastical power, the central monarchy and a trading network. As we understand the outlying zone in the Middle Ages, it was in principle common land that could be made use of by everyone, but only for an individual's needs. One must therefore ask whether such a level of activity must reflect some form of territorial control that is not described anywhere in the historical sources.

The six factors set out above will be discussed individually, in the order in which they have been introduced. Before I begin with that, it is necessary to give an account of the theoretical and methodological framework that will be used as the basis of this analytical work of interpretation.

Outlying Land and Its Use

In the Late Iron Age and the Middle Ages, *jernvinna* was to all intents and purposes associated with peripheral forest zones and lower mountain valleys, areas which nowadays are normally referred to as *utmark*, 'outlying land'. The term can be understood in different ways, and within the discipline of archaeology the aim of studies of the outlying land is principally to draw out and bring into focus human activities outside of the agricultural areas.⁵⁸ The concept of outlying land is a modern one, and it is usually equated with the entire environment outside of what we now call the *innmark* or arable land.⁵⁹ This does not necessarily match how medieval society saw things. The farms of the Middle Ages consisted of an area of arable land and an area of outlying land, separated by the fence. Within the fence there was mostly agricultural land, while the areas outside of it included meadowland, pasture and small woodlands.⁶⁰ Beyond the farm fence lay the 'wild and unknown' landscape: the place in which *Útgarðr* lay in the Old Norse mythological cosmos,⁶¹ and which in the Middle Ages was often common land. Here, our focus falls upon

⁵⁸ Anglert (2008) 231.

⁵⁹ Svensson (1998) 10–13; (2005) 157–170.

⁶⁰ Svensson (1998) 10; Øye (2005) 10; Anglert (2008) 229.

⁶¹ E.g. Steinsland (2005) 99.

the outer zone of the outlying land, the area beyond the limits of the farm properties. A primary task for this work is therefore to form some understanding of the relationship of the medieval population to these outer zones of the outlying land.

Most of Norway has always consisted of this sort of outlying land. According to the modern classification, 97% of the land area is still so designated, made up of 70% mountains and 27% forest,⁶² with only 3% of the land being cultivated. As a result, we must assume that the exploitation of these huge areas was essential to the population and its development. In every period, its resources have been invaluable, be that for hunting, gathering and fishing, for pasture or subsistence, or as raw materials for objects and tools. Despite this, the resource value of the outlying land and its exploitation has often been marginalized and under-socialized in the study of history—and indeed within archaeology to a degree.⁶³ The arable land that was used for agriculture is regarded as the most central—and in many cases the sole—factor in economic development. The mountain and forest regions, with their marginal agricultural activity, have, in contrast, not been regarded with equal interest, probably because these areas are considered to have little economic value.

The recording undertaken in recent years clearly contradicts such a position. It makes it clear that the use of the outlying land in the Iron Age and the Middle Ages was really extensive. These resource areas were important even in earlier periods. The basis for what is defined as ‘outlying’ actually has to be traced back to the Late Neolithic.⁶⁴ When the population introduced permanent forms of settlement, and began, at the same time, to clear and cultivate the land, a distinction between arable land and outlying land came into being.⁶⁵ This does not imply that the same areas were not exploited even in earlier times, but it is clear that the introduction of pastoralism led to the incorporation of the outlying zones in new social and economic structures. However, at the same time as much of the population went over to an agrarian lifestyle, or to live off a combination of agriculture and the resources of the outlying land, there have been cultures in both North and East Norway which have lived and worked entirely in forest, mountain or coastal environments. For groups such as these, it is meaningless to employ the concept of ‘outlying’ land.⁶⁶

62 Holm (2004) 69–70.

63 E.g. Myhre (1973) 14–29; Sandnes (1979) 165–167; Lunden (1988); Skre (1999) 417; Bagge (2010) 51, 70, 113–114.

64 Svensson (1998) 16.

65 Prescott (1995) 163–190.

66 Bergstøl (2005) 203–207.

In the study of outlying land, three principal forms of relationship are reckoned with, which can be examined either separately or together:⁶⁷

- The outlying land together with the arable land as an element in an economic, social and cultural system, in which they play different roles, but are directly interdependent
- Settlements in marginal areas, or 'areas of colonization', where special economic systems and cultural identities are developed
- Outlying land in a wider perspective, under which peripheral areas stand in a relationship of mutual dependency with a central zone, e.g. through the production of goods for a market dominated by the demands of the central zone.

Here, the focus falls upon the crossing point between the second and third forms of relationship, as what is fundamental to this project is the proposition that *jernvinna* in Hedmark is an element within a wider regional system. But the first form of relationship is also integral to this system, as neither the outlying land nor the farm can be studied in isolation without considering the socio-political conditions, elites or power structures.⁶⁸ The archaeologist Irmelin Martens⁶⁹ is one who has stressed that outlying settlement cannot be studied on its own, but rather that economic and social connections with good agricultural areas are crucial to an understanding of the conditions in the marginal zones.

Within the debate over the outlying land, the question of how one should interpret the evidence from these zones in socio-economic terms raises itself. The kinds of cultural monuments and their quantity enable one to classify the use of the outlying land either as an aspect of a domestic economy or as part of a commodity-production system. In order to distinguish between these, the archaeologist Eva Svensson⁷⁰ employs the terms *intensive* and *extensive* exploitation of the outlying land. 'Intensive' use means that the resources of the zone were a significant element in the overall subsistence basis. 'Extensive' use, by contrast, indicates that the outlying land was not of equivalent economic importance. In order to differentiate between these categories, she uses the discriminants of quantity (the number of remains), complexity (the number of categories of outlying land represented) and the hinterland of

67 Andersson (1998) 5–6.

68 Andersson (1998) 7; Heidinga (1999) 410.

69 Martens (1990) 70, 72.

70 Svensson (1995) 139.

the farm (position in relation to the outlying land). Svensson defines the use of the outlying land as intensive if it is complex, has a high number of sites, and is situated peripherally to the farm. She notes, amongst other things, that such exploitation made it necessary for the agents to have resided away from the farm for periods. Extensive use is less substantial, with fewer traces of activity, and this sort of enterprise is usually close to the farm.⁷¹

A similar view has been taken by Martens⁷² in connection with studies of bloomery ironmaking at Møsstrond by Lake Møsvatn in Telemark County. Here, she divides the areas of *jernvinna* into self-supporting settled areas and specialized districts. She uses a density of 5 bloomeries or 50 charcoal pits per square kilometre to define whether an area is producing a surplus. Further, she brings the farms into the discussion, and divides these into four main types: (1) farms whose economy is based upon agriculture within a limited area; (2) farms whose economy is based upon agriculture, but is dependent upon large areas in a variety of ecological zones; (3) farms whose economy is a combination of agriculture and the exploitation of other resources such as hunting and fishing, and thus is dependent upon access to several ecological zones; (4) farms whose economy is largely based upon other resources and not upon the production of cereals or other agricultural products sufficient for its own consumption. In these cases, the farmed area is small and cereal cultivation unreliable because of the climatic conditions.

A problem with this model, as Svensson⁷³ considers, is the chronological depth of the exploitation of the outlying land. In most cases it is not possible to determine how far the various activities, or parts of the same activity, took place at the same time. In this light, the outlying land may have been extensively worked in one period and intensively at other times. When investigating large areas of outlying land, one must therefore prioritize the establishment of phases of use, for instance by undertaking dating analyses, in order to produce good chronologies for the area in question. Narmo⁷⁴ has discussed the problem in connection with his postgraduate thesis on *jernvinna* in the valley of Valdres in the Middle Ages. The excavations at the Dokkfloy site, and the survey work in the valleys of Gausdal and Valdres⁷⁵ provide a basis for this study. Altogether 176 sites of the category '*Jernvinna* together with charcoal pits' ('JKS') were recorded, and by using mean figures for production related

71 Svensson (1998) 13–14.

72 Martens (1982) 29–34, (1988), (1992) 55–67.

73 Svensson (1998) 14.

74 Narmo (1996a).

75 Larsen (1989) 91–113; (1991); Jacobsen and Larsen (1992); Narmo (1996a).

to the number of farms he came to the conclusion that production was undertaken for local needs if one assumes regular production over a period of 350 years. The 14C dates from the investigations at Dokkfloy and the surveys in Gausdal (92 JKS) imply, however, that the majority of the sites are of the period AD 1250–1350. The level of production was thus quite different, with what corresponds broadly to household production (local craft) from AD 1050–1250 and specialized production (a crafts settlement) in the following phase.⁷⁶

Another weak point in Svensson's model is that it defines the use of the outlying land in relation to a single farm or settlement. In her studies, the emphasis lies on the first and second forms of relationship, and the model is adapted to that approach. In systems where the use of the outlying land cannot be related to the hinterland of individual farms but rather is an element of wider patterns as per the third form of relationship, other factors must be included too. These may be studies of the farms and possible boundaries, common rights, quantification and classification correlated with the number of farms, and the extent and organization of the various activities in the outlying land. Both Martens and Narmo⁷⁷ work with areas of settlement rather than individual farms in their studies, as it is impossible to associate the remains in the outlying land with individual places of settlement.

In relation to outlying land and its exploitation, in the present study I shall use Hans Andersson's and Svensson's⁷⁸ conceptual systems, but I shall supplementarily include the agrarian settlement as a unit, and to a lesser degree, consider the position of individual farms in this system.

Regions and Technological Boundaries

In this book, an area of outlying land in the southern part of Hedmark is presented as a discrete, iron-producing region. A key question is how regions arise, and how their boundaries are established. In the discussion that follows, I use the concept of *technological boundaries*. By this, I mean that within different regions one will find different technologies or variations in technology, and that there must necessarily be boundaries to where these varieties are encountered. The boundary can be sharp, blurred or overlapping; and without boundaries it is difficult to define a region, or then to explicate where, how and why a technology developed. The concept is a general one, and can be used for a

⁷⁶ Narmo (1996a) 191.

⁷⁷ Martens (1992); Narmo (1996a).

⁷⁸ Andersson (1998); Svensson (1998).

range of elements such as technology associated with transport, technology involved in construction, technology associated with tools, or technology linked to the conditions of production. An example might be regional variations of the log building technique (*laft*), represented, for instance, by Findalslaft and Vagelaft.⁷⁹ What is interesting in a study of *laft* techniques is not only what differences are actually found in the technology, but also where the boundary between traditions lies, and why it happens to be there. Only by considering that, can one understand the dynamics of development in the various regions.

My study area can thus be understood as a region that was home to one technology, clearly delimited, geographically, from other technologies whose purpose was the production of iron. What this variation consists of will be meticulously presented and discussed in due course. At present, it is sufficient to affirm that there is clear variation. But how and why did any such contrast emerge between this region and others? And what is it about this society that led to a specific technology being adopted here? We can sketch some general possibilities. The reasons may be manifold. A region may be based upon natural geographical conditions such as topography, geology and vegetation. A region may also derive from social structures, such as the development of settlement, property conditions, and political control. Regions may further be distinguished from contact zones, communication arteries and networks. The use of resources may contribute to the determination and delineation of regions. This would of necessity have to be linked to access to some raw material, but it can equally well be considered in connection with the choices and methods of a society or a group, often in order to express an identity that is integral to the community in question. In the discipline of geography, landscape, boundaries and regions are discussed in several contexts, and many attempts have been made to find good general criteria for the phenomenon.⁸⁰ In particular, how the identity of a group or a society should be understood in relation to their own or others' territories is regarded as a problem. Technology and variations of technology are included within this debate. This type of problem is discussed in many different disciplines, including archaeology.⁸¹

Fundamental to many studies is the fact that explanatory models are too simple. They do not take account of all the crucial factors within a complex system.⁸² Within the discussion of technology this is particularly the case with

79 Weber (2002) 69.

80 E.g. Lefebvre (1991); Paasi (1996), (2010) 15–33; Jacobs (2006).

81 E.g. Larsson (2008) 241–264; Strömberg (2008); Barndon, Engevik and Øye (2010); Rundberget (2012) 191–204.

82 Jacobs (2006) 1–4.

the understanding of the term *technology* itself. The subject has been widely discussed in social anthropology and archaeology over the past two decades. I discussed one such example by way of introduction: that research into *jernvinna* has been criticized for paying too little attention to anything other than technical aspects of the process. As a result of the continuing debate over technology, *jernvinna* has become part of the social sphere of the population.⁸³ A common thread in this research is that the theories have embraced concepts such as *habitus*, technological choice, technological style, *chaîne opératoire* and social agency, and its ideas have been taken from scholars such as Heidegger, Mauss, Pfaffenberger, Lemonnier, Dobres and Ingold.⁸⁴ Central to the debate is the idea of an opposition between the broad view of technology of the ancient world and a rational modern perception which derives from the Enlightenment's idealistic aim to discover exact sciences in order to conquer Nature. In the latter view, technology has been fragmented and reduced to merely a means of production.⁸⁵ Bryan Pfaffenberger describes the modernistic concept of technology as 'The standard view of technology',⁸⁶ according to which 'All around us are artifacts originally developed to fulfil a specific need...'.⁸⁷ More recently, Marcia-Anne Dobres⁸⁸ has described this as 'Practical reason ontology', in contrast to the broader 'Cultural reason ontology', which includes the society. In Norwegian research on *jernvinna*, such a perspective has predominated until recent times.⁸⁹

The term 'technology' itself is derived from Greek *technicos*, which is a compound of the words *technē* and *logos*. *Technē* can be translated as 'art', 'finish', 'know-how' and 'craft', terms that are closely interrelated. *Technē* denotes the structure of objects both through words and use, and was regarded by the Greeks as part of the structure of human existence.⁹⁰ The term is therefore used only partly in respect of functionality and production. As I understand it, *technē* was in this way juxtaposed with human cultural activities.⁹¹

In the wake of critiques of the 'standard view', it has become essential to regard technology as a total social phenomenon. This is a material, social and

83 Rundberget (2002a), (2009) 67–85; Bjørnstad (2003); Barndon (2004) 21–36; Haaland (2004) 1–19; Tveiten (2005); Wintervoll (2010).

84 Heidegger (1977); Mauss (1979) 97–122; Pfaffenberger (1992) 491–515; Lemonnier (1993); Dobres (2000); Ingold (2000).

85 Heidegger (1977).

86 Pfaffenberger (1992) 492.

87 Pfaffenberger (1992) 493–495.

88 Dobres (2010) 104–106.

89 See Rundberget (2002a) 30–32.

90 Mitcham (1979) 173.

91 Rundberget (2002a) 28.

symbolic phenomenon, and its elements cannot be treated individually because they belong to a larger system.⁹² This sort of approach to technology as a phenomenon has proved to be effective in explaining aspects such as relationships between technology and society, ideological and social factors associated with individuals and groups, and aspects of knowledge (experience, finish and skill) in craft and production.⁹³

Altogether, then, technology must be regarded as an integral feature of a society. It may be the expression of a particular group's choice of methods in some technology, and it can be defined by delimitation by the geographical working area of this group, contrasted with the technological approaches of other groups.

The way in which technological boundaries emerge, are developed and are used, is a composite process. To begin with, we have the physical landscape with its potential and resources. Another factor is both internal and external influences, which may be of social, political or economic form. Finally, there is our—i.e. the individual's or group's—relationship to and understanding of the same landscape. I have previously argued that both the physical and the mental are crucial in an understanding of the choice of methods and the organization of *jernvinna* in the Gråfjell area.⁹⁴ This introduces socio-political factors as well. This has also been pointed out by the archaeologist Randi Barndon⁹⁵ when she suggests that power and control of a landscape must be a central element in holistic views. A similar conceptual system has been described by the sociologist and culture geographer Marteen Jacobs.⁹⁶ In order to understand a landscape, which is understood here as a bounded area with a particular technology, he proposes three elements which should be considered in connection with the aforementioned factors: *Matterscape*, *powerscape* and *mindscape*. This tripartite conceptual structure, in combination with the broad understanding of technology, will be used as the foundations of the following discussion of *jernvinna* in Hedmark.

Exploiting the Landscape

In research on *jernvinna*, the use of the landscape is normally studied with a view to identifying possible variables between traditions. This is particularly

92 See Pfaffenberger (1988) 236; also Mauss (1979); Lemonnier (1989) 156.

93 Rundberget (2002a) 39, Fig. 1; (2012).

94 Rundberget (2009).

95 Barndon (2010) 245–246.

96 Jacobs (2006) 8–12.

well reflected in the work of Narmo,⁹⁷ who uses organization within the landscape, together with factors such as morphology and organization at the bloomeries, in order to define different traditions of *jernvinna* in the Middle Ages (see also Ch. 2, The distribution and organization of slag tapping shaft furnaces in south-eastern Norway).

The location of *jernvinna* is often clearly linked to the exploitation of resources, a feature that has varied through time.⁹⁸ In the Early Iron Age, in Trøndelag and Agder, one finds that bloomeries were primarily linked to rivers or lakes.⁹⁹ The archaeologist Gert Magnusson¹⁰⁰ has observed the same phenomenon in Jämtland, and describes the sites of the Early Iron Age as *shore-bound*—in contrast to the *forest-bound* sites that emerge in the Middle Ages. Several scholars have treated the link with water as something natural, since there would be a need for drinking water, and water for putting out the fire.¹⁰¹ There has also been speculation over the extent to which sites with sources of running water might be associated with water-driven bellows.¹⁰² This, however, is not demonstrable before the Early Modern Period in Norway, except at one Evenstad site near Sandnesbekken in Tolga Municipality in the northern part of Hedmark County, which might be datable to the Late Middle Ages.¹⁰³

In the case of southern Norway, Magnusson's model is not, in chronological terms, fully applicable. Sites from the Early Iron Age in the east, the so-called 'Østland furnaces', often are not situated close to water.¹⁰⁴ At Møsstrand, where iron production was practised in the Late Iron Age and the Middle Ages, the majority of sites are closely linked to water or bog.¹⁰⁵ Indeed, proximity to bog is another factor in positioning. In contrast to closeness to water, this association is more general, with no limitations in terms either of date or of tradition. Proximity to bog may therefore be an element with both shore-bound and forest-bound production sites. The state geologist and natural scientist Rolf Falck-Muus¹⁰⁶ stressed that the sites in Hedmark were placed on drier locations close to the sources of the ore. He also observed that there was often

97 Narmo (2000) 139–147, (2003a) 139–141, 146.

98 E.g. Rundberget (2008) 16–33; Larsen (2009) 96.

99 Stenvik (1991b) 411–421; Rundberget (2008); Espelund (2005) 126; Kallhovd and Larsen (2006) 237–253.

100 Magnusson (1986) 236–237.

101 Hauge (1946) 20; Stenvik (1990) 210; Bloch-Nakkerud and Lindblom (1994) 37.

102 Bloch-Nakkerud and Lindblom (1994) 37; Larsen (2009) 95.

103 Espelund (2005) 83, 141–142.

104 Larsen (2004); Rundberget (2008).

105 Martens (1988) 97.

106 Falck-Muus (1931) 61.

running water close by, and that sites were placed in the neighbourhood of shielings. Martens¹⁰⁷ shows that the bloomeries at Møsstrond are often placed on dry land close to the edge of the bog. At the Dokkfloy site, the bloomery sites lie on well-drained moraine with a good supply of wood, by preference on forested 'islands' of moraine within what is otherwise a flat boggy basin.¹⁰⁸ In Trøndelag, the sites of the Early Iron Age are sited up by the mountains and the mountainous areas with large areas of bog.¹⁰⁹ The archaeologist Line Bårdseng¹¹⁰ has discussed the positioning of iron bloomeries in relation to bogs and water in Hedmark and discovered some regional differences. The explanations for this may be the frequency of bogs in relation to the number of ironmaking sites, the quality of bog ore, or that the site has been selected on the basis of old beliefs and tradition. A question that arises in this context is *proximity to which bog?* Bogs are classified in different ways on the basis of criteria such as development (bog-formation), topography, geology and vegetation¹¹¹ (See also Ch. 2, Bog ore and roasting sites). Consequently, a bog is not just a bog; and a weakness in several of the studies referred to above is that this point is not included amongst the relevant factors when explanations are sought. One cannot therefore say that proximity to bog is directly related to access to resources.

Magnusson¹¹² also emphasizes proximity to bog in particular in the case of forest sites. The use of the term *forest-bound*, however, is somewhat problematic in my view, as practically all sites either lie, or had lain, within areas of forest. In every significant respect, then, shore sites will also be forest sites. Forest sites in this context must therefore primarily be understood as production sites that are not placed in the immediate vicinity of a source of water. This type of site, as Magnusson points out, belongs principally to the end of the Iron Age and the Middle Ages. All of the *jernvinne* areas in Norway have medieval sites that are located by a water source, but with the exception of the previously mentioned Møsstrond, the dominant trend is for production to be subject to other positioning factors. In the case of Møsstrond it should also be noted that the studies took place in the shore zone, and that here too there are sites that are not directly associated with water.

107 Martens (1972) 98.

108 Narmo (1996a) 27.

109 Stenvik (1990) 210; Rundberget (2005) 67.

110 Bårdseng (2003) 378–280.

111 E.g. Pettersson (1982) 45 and Rueslåtten (1985) 31–38. See Rundberget (2007) 304–305.

112 Magnusson (1986) 54.

In the Early Iron Age, as already noted, *jernvinna* in eastern Norway was subject to different positioning considerations from those in Trøndelag and Agder. This applies likewise to the conditions of settlement. The bloomeries are often found close to mountain farms and transhumance sites. The discussion of the association between *jernvinna* and mountain farms and shielings has been pursued in many contexts. The mountain farm theory is associated with the archaeologist Bjørn Hougen,¹¹³ who distinguished mountain farms at which *jernvinna* was practised. The archaeologist Tom Bloch-Nakkerud¹¹⁴ has more recently shared this view. Other scholars have leant towards the shieling theory, where *jernvinna* was practised alongside transhumance.¹¹⁵ Martens perceives a development in which a shieling economy developed into permanent settlement, with iron production following this development.¹¹⁶ Narmo, however, points out differences between Dokkfløy and Gausdal,¹¹⁷ and regards both systems as plausible in the Early Iron Age. Other scholars consider that such an association is insecure, and consider transhumance as a consequence of iron production.¹¹⁸ The archaeologists Bjørn Myhre and Lars Stenvik suggest that *jernvinna* was a precondition for the establishment of shielings on the basis of clearance and preparation. In Trøndelag this has been argued on the evidence of pollen series which show that, *inter alia*, transhumance took over after iron production had been ended.¹¹⁹ Stenvik also considers that the correlation in patterns of positioning may be linked to the natural situation: well-drained ground, access to water, and good ground conditions for building.¹²⁰ The archaeologist Kjetil Loftsgarden¹²¹ further emphasizes that there are so many sites associated with shielings in comparison with sites in the forest because these are comparatively easy to identify during survey work in contrast to sites within woodland, and that the picture may therefore be skewed. Loftsgarden makes a good point here, but it should be added that there are clear differences between regions. In areas where linkage with farms or shielings is extensive and clear, I consider that this situation is connected to the organizational structure. This is clearly shown in the Early Iron Age in eastern Norway,

113 Hougen (1947) 17, 294.

114 Bloch-Nakkerud (1987) 147.

115 Hauge (1947) 20; Reinton (1957) 259–260; Larsen (1991) 283–284; Jacobsen and Larsen (1992) 167–174.

116 Martens (1988) 118, 125.

117 Narmo (1996a) 136–137.

118 Stenvik (1996) 36; Myhre (2002) 88; Tveiten (2008) 47–48.

119 Solem (1991) 58.

120 Stenvik (1996) 36.

121 Loftsgarden (2007) 55.

where a large number of sites are found in forest areas close to settlement. In the Viking Period and the Middle Ages, the picture changes somewhat as extraction moves further out into the forests and the long valleys. A connection between settlement/shielings and bloomery ironmaking is not so clearly demonstrated for this period. One of the reasons for this is, as Loftsgården correctly points out, that information on settlement and shieling sites in the Viking Period and the Middle Ages is scarce in outlying areas where *jernvinna* is well mapped; this is manifestly a reflection of which areas have been investigated and which have not.

The archaeologist Bo Strömberg has discussed the siting of *jernvinna* in Halland in Sweden on the basis of factors such as the quality and quantity of slag heaps in various landscape zones, the position of the farm, and the relationship between farmed land and outlying land. The picture he produces agrees well with that from Norway in terms of association with farms. He produces three models governing position:¹²²

- Farm-based ironmaking: where production is linked to the farm. Raw materials are taken to the settlement. Smithing is linked with ironmaking. The level of production was relatively low.
- Raw material-based ironmaking: where production is located in areas close to the outlying land that are rich in ore and wood. Preliminary smithing and consolidation are part of production, but secondary smithing was practised at the farms. The level of production was relatively high.
- Energy-based ironmaking: where production was situated by streams and rivers where water power was used to drive bellows or hammers for preliminary smithing. Secondary smithing was undertaken at the farm or in a town. Ore and wood were readily available. Production was to the level of a massive surplus.

Strömberg's model is chronologically governed, in that the first category is linked to the Early Iron Age and earlier Middle Ages, the second to the Late Iron Age, the Middle Ages and the Early Modern Period, and the third to the Late Middle Ages and Early Modern Period. In contrast to Norway, where energy-based sites are virtually unknown, Sweden did see the development of water-powered bellows and their use in *jernvinna*.¹²³

In this overview, I have shown that the use of the landscape varies both spatially and temporally; however, naturally enough, there are several recurrent

¹²² Strömberg (2008) 37–39.

¹²³ Strömberg (2008) 119–148.

features. I have already noted a few weaknesses in the studies. Physical aspects, such as where the ore was roasted, and access to communication routes, understood here as road-systems from the place of production to the farm or settled district, have to be included if possible, to complete the picture. Such a discussion has been conducted by the archaeologist Ylva Stenqvist Millde concerning Norrland in Sweden. In her dissertation, she has, amongst other things, considered the relationship between bloomeries, summer pastures, and route-ways. Proximity to a routeway is defined as a distance of less than 200 m. She concludes that good lines of communication and the presence of ore govern the positioning of bloomeries in the landscape. They are not necessarily close to route-systems, but ideally in open areas, by boggy basins or lakes, which facilitate transport in the winter.¹²⁴

The discussion shows that the study of the positioning in terms of the exploitation of resources is a complex matter. One has to take account of a series of factors in order to be able to analyse and interpret the use of a landscape in relation to a specific technology such as iron production. Fundamental to any form of production has to be one or more raw materials, and it is appropriate, therefore, to start from this. In the case of iron production, bog ore and a source of energy (wood/charcoal) are the most essential elements. There is also the construction material, primarily stone, clay and wood. This can be more fully defined as a question by introducing Jacobs's tripartite system. In this conceptual perspective, the raw material is described first and foremost as *matterscape*, the physical environment around us. Raw material can be studied for itself here: what it consists of, its quality, how it is obtained and used in production, how much is produced, and so on. In the study of *jernvinna*, raw material as 'matterscape' is thus primarily concerned with scientific and processual lines of research. However, if one studies the raw material and its exploitation in a landscape, the raw material will also represent *powerscape*: for instance, who can extract it; where building wood can be collected; how much can be taken; who controls the industry which this raw material belongs to; and the economic framework that is the basis for the exploitation of this raw material. Seen in this light, 'powerscape' has one foot in the socio-economic tradition of research that archaeologists have represented. Raw material can also be defined as a *mindscape*: the building material, its working, or methods of production, etc., may reflect the decisions of individuals, a group or society, with respect to how the technology will be practised, where production belongs on the basis of customs and belief. Under this heading belongs a focus on more mental and agent-oriented aspects which have come in with the theoretical

¹²⁴ Millde (2007) 128, 141–145, 156–160.

trends of the most recent decades. In a study of positioning, therefore, one has to take a complex set of factors into account in order to be able to understand the context within which it is placed. In the following landscape analyses, this is exactly the starting point that I use in an attempt to interpret the reasons for the distribution as it appears in the Gråfjell area.

The Economic Context of *Jernvinna*—Domestic Activity, Craft or Something More?

Economic Conditions in the Viking Period and the Middle Ages

A core feature of production is the economic significance it had for a society, be that on a local, regional or supra-regional plane. Before I proceed further with this discussion, however, it is appropriate to explain how one can interpret the *economy* and *trade* of the Viking Period and the Middle Ages. The economic frameworks of the Viking Period and the Middle Ages have been linked to the exchange of goods rooted in the social relations of the population in much scholarship, and only to a minor degree to market-directed systems such as we have today. In Norway, the historian Kåre Lunden¹²⁵ has been an advocate of this approach, which derived from the economic anthropologist Karl Polanyi's substantivist theory.¹²⁶ Behind Polanyi's theory is the view that a market-dominated economic theory is a modern, western phenomenon which cannot be used in studies of early and non-capitalist societies. Lunden uses Polanyi's substantivist theory and the concepts of *substantive economy* and *formal economy* in order to distinguish these units. By 'substantive economy', Polanyi refers to the interaction between people and the material and social environment as a means to satisfy material needs. The economic perspective of a pre-industrial society is therefore those strategies that are used in order to obtain, produce and consume goods or services. 'Formal economy', by contrast, is linked to a market-oriented economy, where the goal is to maximize returns and minimize costs.¹²⁷ Economic theory has three preconditions: money (common items of value), fluctuating prices and a market. Lunden¹²⁸ considers that these preconditions cannot be demonstrated through studies of economic relations in pre-industrial societies much of the time. For this reason,

¹²⁵ Lunden (1988).

¹²⁶ Polanyi (1957) 243–270.

¹²⁷ Polanyi (1957) 243–244; Lunden (1988) 24.

¹²⁸ Lunden (1988) 30–33.

other crucial factors have to be included.¹²⁹ He outlines these by discussing three economic models—the mutuality principle, the redistribution principle, and the market principle—to which the institutionalization of economic life is fundamental. At the heart of Lunden's ideas is that the motivation of the economic sphere was not profit but rather the maintenance of social relationships in order to protect oneself from problems in times of difficulty.¹³⁰

The substantivist approach of Polanyi, and Lunden in his wake, has been justly criticized because it allows very little place for market trade. In other words, factors such as supply and demand, and the profit motive, are not included within the social relations of pre-industrial society.¹³¹ According to Lunden,¹³² trade is a very wide concept, which includes all forms of exchange of goods. In contrast to this is the position of the historical archaeologist Peter Carelli,¹³³ who considers that trade is primarily for the sake of gain, but that there may also be a social profit. The historian Knut Helle¹³⁴ goes further still, in stipulating that a trade must include the buying and selling of goods. Social and political gain may be a feature, but only as a secondary outcome.

The economic model that Lunden prefers to attribute to the Viking Period and the Middle Ages is a redistributive exchange of goods supplementary to gift exchange. This trade was not based on profit, but the motive was rather socio-political in character, aimed at obtaining and redistributing goods in order to establish and maintain alliances. A similar view has been propounded by the historian Jón Viðar Sigurðsson.¹³⁵ He believes that trading by chieftains and leaders of the Viking Period was not motivated by profit but proceeded in the form of a gift/reciprocal gift system. Sigurðsson considers that there was also some trade within a market framework, but that it was primarily farmers who were responsible for this as they exchanged consumer goods without necessarily involving friendship or alliances.

In the past decade, several scholars have radically diverged from Lunden's views. Through the Kaupang research project, the archaeologist Dagfinn Skre has shown that there were clear market-economic features in the period AD 600–1000. Goods were produced for sale, and gold and silver were used as a form of currency, at the same time as there was a market in which prices were

129 Lunden (1988) 36–50.

130 Lunden (1988) 51–89.

131 E.g. Lie (1991) 219–235; Helle (2009) 572–609.

132 Lunden (1988) 52.

133 Carelli (2001) 178–182.

134 Helle (2009) 584.

135 Sigurðsson (1999) 49–52.

determined and changed on the basis of supply and demand.¹³⁶ In the Middle Ages, the trading in the medieval towns, particularly Bergen, is also highlighted as proof that there was extensive market trade. Helle¹³⁷ regards it as inconceivable that Bergen could have achieved such a strong position if its trade were limited to the business affairs of kings, the Church and the aristocracy. A further central point derives from studies that split with the substantivist school over the absence of a monetized economy. The numismatist Svein H. Gullbekk demonstrates that minting in Norway was widespread from the middle of the eleventh century onwards, and that, especially in the towns, coinage was used as a means of payment in the High Middle Ages. However, coins were also used in payment in rural settled areas, for instance, in trade in land.¹³⁸

According to Helle,¹³⁹ what he calls the 'primitivistic' or anthropological approach should not be applied uncritically, when the so-called economic 'otherness' that Polanyi and his supporters attribute to prehistoric societies is not in fact so very different. The examples given above show perfectly clearly that both in the Late Iron Age and in the Middle Ages there was significant market-based trade in which goods were produced and sold or exchanged with a view to profit. In the study of *jernvinna*, both directions can be traced, but the idea of a redistributive economy has been foremost. Nonetheless, several studies of *jernvinna* also show that market demand has been treated as determinative in the establishment and sustenance of *jernvinna*. In what follows, I shall draw out a number of examples of both approaches, before exploring a model that I personally regard as a good approach for my own study.

Economic Models in the Study of Jernvinna

The archaeologist Arne B. Johansen¹⁴⁰ offered a hypothesis of 'cultural dualism', when he argued that *jernvinna* in the Early Iron Age was adopted by hunting populations in the mountains in order for them to exchange the iron produced for grain from the settled areas. The farms already had meat, hides and fish, but they needed access to iron. At the same time, Johansen took it for granted that this production was time-consuming, and that it undermined the traditional system of food-supply by occupying manpower in the middle of the hunting season. As a result, the earliest *jernvinna* came to an abrupt

¹³⁶ Skre (2008) 327–335.

¹³⁷ Helle (2009) 589.

¹³⁸ Gullbekk (2009) 245–249, 289–304.

¹³⁹ Helle (2009).

¹⁴⁰ Johansen (1973).

end.¹⁴¹ A.B. Johansen here points to an economically motivated inception of iron production, and to the establishment of a network based upon reciprocity between a hunting population and the farms down in the valley. This theory has been criticized in several contexts¹⁴² and has little support nowadays.

From the last phase of the Early Iron Age to the Middle Ages (AD 500–1200), A.B. Johansen considers that *jernvinna* was linked to agrarian settlement as the bloomeries were for the most part located close to the summer pastures.¹⁴³ He assumed that the household was involved in a cyclical shift between agriculture, iron production and reindeer hunting.¹⁴⁴ Similar cyclical activities are suggested to have been practised at Dokkfløy in the Early Iron Age¹⁴⁵ and at Hovden in Bykle, Aust-Agder.¹⁴⁶

Jernvinna as a feature of the annual cycle of the farm is associated both with the farm's internal economy—in other words, as A.B. Johansen interprets the system around Hardangervidda in the Late Iron Age and the Middle Ages—and with craftwork: in other words, with a degree of surplus production. The economy of self-sufficient communities may be based upon both the principle of mutuality and the principal of redistribution. But the more self-sufficient a farm is, the more one must suppose the system to have been based upon the first of those principles. In this model, gift exchange between peers is a central premise. Iron production associated with such a society is regarded as marginal, and directly dependent upon individual farms' particular needs. In Norway, this style of production is known from Østerdalen in more recent times through the Evenstad tradition,¹⁴⁷ which is primarily considered to involve a really small-scale farm furnace.¹⁴⁸ As already noted, though, aspects of *jernvinna* in earlier periods are also considered to have been on this scale.¹⁴⁹

Narmo¹⁵⁰ has discussed the validity of the romantic national 'myth of the self-sufficient farming community'. He is critical of much of the earlier scholarship, and argues that it holds too closely to the Evenstad tradition. At the

141 Johansen (2004) 89.

142 E.g. Narmo (1996a); Johansen (2003).

143 Johansen (1983) 127.

144 Johansen (1973) 92.

145 Jacobsen and Larsen (1992) 177–178.

146 Bloch-Nakkerud (1987) 142–143; Wigestrands (1991) 15.

147 After Ole Evenstad, *Afhandling om jernmalm som findes i myrer og morader i Norge og omgangsmaaden med at forvandle den til jern og staal* (1782).

148 Espelund (1995) 46–54; (2005).

149 E.g. Jacobsen and Larsen (1992) 104–105; Narmo (1997) 189–191, (2000) 133; Risbøl (1997) 7–23.

150 Narmo (1997) 13–14, 186–190.

same time, he also criticizes elements of medieval research in which one finds the view that rural settled districts saw only domestic production, in contrast to the urban production of goods,¹⁵¹ and further that such domestic production hindered the development of craft as a factor leading to urbanization.¹⁵² According to Narmo, the evidence indicates that there was surplus production in East Norway and Trøndelag in the Early Iron Age. From around AD 700 there was a marked decline, in association with which production has to be considered to have been primarily domestic, before it increased again in East Norway from the middle of the tenth century. Narmo associates this with unstable political circumstances, the disappearance of markets, and a collapse of the economic system (gift exchange). Iron production came to an end, something which also led to the abandonment of farms. Narmo considers, therefore, that it was not demand and need that were determinative in the subsequent upswing, because a new settlement pattern had to be created before the production of goods could get going again.¹⁵³ This could happen by the new marginal areas, established for subsistence occupation, being brought into use when the economic basis collapsed in areas in political crisis. Around AD 950, *jernvinna* reappeared as a form of production of goods. This coincides with urbanization, and Narmo regards that the kingship could guarantee stable trans-regional exchange of goods—not through those with power in society being directly engaged in production, but rather as the conditions for secure receipt and exchange re-established the basis for stable production. According to the art historian Robert Kloster,¹⁵⁴ the rural craftsman was the one who undertook production for a local market, while craft settlements had a population that was occupied in the production of goods for external markets.¹⁵⁵ Although it is not defined by Narmo, one has to reckon with the rural craftsman as also being part of a gift-exchange system with approximately equal participants. At the transition to the craft settlements, Narmo also reckons on external agents playing a key role, and that there was a move into a redistributive system based on the exchange of goods between settled districts, trading sites and towns. He describes this as a partially commercialized system, in which there was a rational maximization that lies somewhere between the substantive and the formal economy.¹⁵⁶

151 Gjøøl Hagen (1994) 29–57.

152 See Narmo (1997) 14.

153 Narmo (1997) 89–190.

154 Kloster (1947) 1–19.

155 Narmo (1996a) 189.

156 Narmo (1997) 100.

Martens has adopted a different economic model, the so-called 'specialization theory'.¹⁵⁷ In her work at Møsstrand she draws out two scenarios: that *jernvinna* was either a particular use of outlying land for the settled districts in the vicinity, or a particular use of outlying land for economically strong areas further away. In both cases, production requires a stable trading network for the distribution of the goods. She regards the former model as the most probable, but considers that the situation changed over time. At an early stage, extraction was based upon impermanent farms or shielings. As the volume increased, she regards it as natural, however, that *jernvinna* would have been practised from a permanent agrarian settlement based upon pastoralism, for which iron production was a component of the farm economy.¹⁵⁸

Stenvik¹⁵⁹ has interpreted *jernvinna* in Trøndelag in the Roman Iron Age as an element of a redistributive economic system. He assumes a system with local leaders at the core who received and redistributed the iron, partly to local, dependent clients, and partly to larger regional redistribution centres where chieftains controlled the exchange of goods with external markets. He develops a model in which chieftainships exchanged iron for exclusive goods such as hides and furs from North Norway. These were in demand on the Continent and through the southerly trade network they were exchanged for Roman luxury goods.¹⁶⁰ The archaeologist Torkel Johansen¹⁶¹ has shown that the connection between iron production and imported goods in graves in Trøndelag is more complicated. He points out that it was only when iron production had begun to decline that the quantity of imports reached a peak. In the course of the Early Iron Age, society also underwent changes at the supra-regional level, and this had an impact on power relations in Trøndelag from the Roman Iron Age to the Merovingian Period. Johansen considers several chronological scenarios, and concludes that, in addition to its use in warfare, iron was a central trade good in various economic and political networks between Scandinavia and the Roman Empire.

The works referred to above thus present several different scenarios, with different economic viewpoints. What they share, however, apart from A.B. Johansen's hypothesis, is the association of production with a farming society and the view that the activities were undertaken by a local farming population, while gift exchange, redistribution, and to some extent the production of goods

157 Martens (1988) 118–119.

158 Martens (1988) 120–125.

159 Stenvik (1987) 111–114.

160 Stenvik (1991b) 420.

161 Johansen (2003).

for market trade, are the suggested economic systems. Several of the examples also show that the systems were not static but rather changed with time, and that they display the impact of both substantive and formal economies.

To conclude this discussion, I shall return to Lunden. As discussed, it has traditionally been agriculture and agrarian units that have been regarded as the primary factors in the economic development of Norway. This is categorically the case with Lunden, although he also considers *production* in a somewhat wider sense.¹⁶² According to Lunden, production was the essential economic activity. In early societies, where the farm units are based around the institution of the family and on self-sufficiency, he does not see production as a goal in itself but rather as a means to maintain the social unit—in other words, in a thoroughly substantivist spirit. Units of this type are described by Lunden as ‘multi-functional’: they fulfilled a range of social roles prescribed by the substantive economy. The absolute opposite of this are mono-functional modern industries where profit is the sole aim. In an intermediary place between such institutions, in Lunden’s view, lie larger units such as major farms and estates with their hierarchical systems. These institutions had fewer functions than the multi-functional ones, and production is directed towards some surplus for the elite, but without profit being the most important and ultimate aim.

This intermediary place can, in my view, serve to an extent as a starting point for achieving an understanding of the economic world of the Middle Ages. In contrast to Lunden, however, I also believe that smaller farm units belong to this category, as self-sufficiency cannot possibly have been the sole nature of a medieval settlement unit. It is clear that both small agrarian farms and larger farming complexes included production of a non-agrarian character in their economies. This is true for all societies, but the extent varies according to need, opportunity and demand. In good agricultural areas, for example, hunting and gathering may have been supplemented by the production of food and clothing without having been essential for life. In areas where agriculture is more marginal and the soil alone is not productive enough to support life, other forms of production have to be essential in contributing to the farm’s primary needs. At the same time, I mean that in this sort of region there were settlement units whose primary basis did not lie in agriculture but rather in other sorts of production. This means that there is a further institution which Lunden did not allow for. A key starting point in marginal agricultural areas, as far as I can see, is that from an early stage it was essential to create a stable network through which one could exchange or trade in the goods one had produced. Both agriculturally marginal and non-agrarian settlements needed

162 Lunden (1988) 89–93.

agricultural products, and especially grain. They could gain access to these by building into the system a structure that was partially based upon redistributive exchange and partly on market-governed trade. This sort of system does not establish itself, however; it depends upon the power of chieftains, the aristocracy or kings, all of whom have an interest in maintaining and building alliances, and who—in contrast to Lunden's view—had profit as an important aim. And once such a system is set in motion, all is set for the establishment of additional settlements that would further stimulate economic growth in the region. The study area here is, in my view, and as I shall discuss further, an area where this type of system was established and developed during the Iron Age and the Middle Ages.

Jernvinna as an Industry?

Jernvinna as a domestic practice or craft meeting local or regional needs has already been incorporated within models. A further aspect that has been brought out from time to time is that iron production considered in terms of volume can be regarded practically as an industry.¹⁶³ If we think about the meaning of the term 'industry' (Latin *industria*, 'diligence', 'application'), it is a form of economic activity that is characterized by raw materials being transformed into finished products, and by production on a major scale. The invested factors such as labour and machinery are exchangeable, and it is necessary to have major preliminary investment if a profit is to be gained. In an industry, production is standardized. Industrial undertakings could therefore produce much more efficiently than ordinary craft activities.¹⁶⁴

In my view, following the discussion above, despite the theory of market-based production, it is highly problematic to define *jernvinna* as an industry. The criteria of economy (a strong market economy based upon investment and profit), the use of labour (exchangeable power based upon paid work) and factory production (mechanized production-line activity) are decisive in determining that the concept is inappropriate. Factors such as the production of a surplus and standardization of practice with profit as a goal are nonetheless elements that can be associated with *jernvinna* in the Middle Ages.

A less-used term which incorporates these elements is *proto-industry*. As far as I am aware, this term has been used in relation to Norwegian *jernvinna* only

163 E.g. Petersen (1923) 74–75; Hauge (1952) 470; Magnus and Myhre (1976) 227, 301, 438; Espelund (1986); Stenvik (2005) 112.

164 Industry is characterized particularly by the factory-based production of goods, but the activity can also be undertaken at workshops or in the worker's home.

once,¹⁶⁵ albeit without being defined there. The term 'proto-industry' derives from the economic historian Franklin Mendels's article of 1972. He introduced it when, in his studies of Flanders, he recognized a stage of industrialization preceding mechanized industrialization. This *proto-industrialization* took place, in his view, primarily in the period AD 1650–1900. In this period, most labour was involved in traditional, rural, market-oriented craftwork. Behind it lay a growing need for labour in connection with agricultural harvesting—labour for which there was no need at other times of the year, however. By making use of this labour, productivity was increased by increasing the number of workers outside of the harvest season. As a result, craft activities could be organized on a more permanent basis.¹⁶⁶ Agriculture was still the principal activity, and the new proto-industrialization stood in second place; at the same time, crucially, the workers had a foot in both camps.¹⁶⁷ Mendels's proto-industrialization is associated with home-based production intended for an inter-regional market. Through proto-industrialization Mendels also perceives changes in the spatial organization of the rural economy, as a market for agrarian goods was created, supplying the group that was not self-sufficient. Mendels¹⁶⁸ has three different explanations for why proto-industrialization started off. One is that there was a rise in population in the form of migration to agrarian areas. He sees another cause in increased production deriving from greater efficiency developed to compensate for unreliable income. Finally, he suggests that proto-industrialization was a result of the colonization of new land and the opening up of new trading networks. This could lead to regional specialization.

The social historian Leslie A. Clarkson¹⁶⁹ has discussed this concept on the basis of Mendels's basic ideas, and has defined four specific features which characterize proto-industrialization: (1) production for external markets; (2) that production was undertaken by a group formed of a combination of farmers and producers; (3) that production stimulated the commercialization of agriculture through food becoming a market commodity; (4) towns and trading sites came to be located in production zones as centres for trade as an activity.

Clarkson¹⁷⁰ emphasizes that this theory is based upon the premise that there should be gradual change. From this, Marxist approaches have linked

165 Risbøl (2005) 53–65.

166 Mendels (1972) 241–242.

167 Mendels (1972) 258.

168 Mendels (1972) 249.

169 Clarkson (1985) 15–16.

170 Clarkson (1985) 12–13.

proto-industrialization to the transition from a feudal society to capitalism. Proto-industrialization is a transitional step, as capital began to become involved in production to a greater degree, either through the relationship between capitalists and paid workers or through craftsmen in the home serving as low-level suppliers and capitalists through a 'putting out system'.

Mendels's idea of proto-industrialization has been criticized as overly rigid, and for fitting poorly with the history of many industrialized lands, including Norway.¹⁷¹ I note a number of the core criticisms here.¹⁷² Mendels's chronological limits are difficult to subscribe to. AD 1650 is proposed as the starting point, but the earlier development of industry like this is not unfamiliar. Moreover, proto-industrialization can appear in many different agrarian zones, not just rich ones, and in towns too. Many who lived in towns did several jobs in order to maximize their income. Mendels has also been criticized for not defining the 'region', and so creating a problem in defining 'external markets'. A further criticism is the matter of scale: what is counted as industry? When is production 'craftwork'? And how much needs to be produced to qualify as a proto-industry? Most important of all, however, is the fact that many working groups are excluded by definition, including those who produce for local contexts (e.g. tanners and smiths) or production that requires capital (e.g. mining and milling). A crucial critical observation is also that the contextual relationship between social development and proto-industrialization is given too little attention.¹⁷³

Following this criticism, many have concluded that Mendels's theory is too specific and under-productive to employ in their own areas of study.¹⁷⁴ A contribution of interest to this debate is the historian Jürgen Schlumbohm's view that, although the concept of proto-industrialization is strongly associated with Mendels's theory, the concept of 'industrialization before industrialization' may be valuable if freed from that strong definition.¹⁷⁵ The definition may therefore be a good conceptual instrument in explaining macro-structures in pre- and proto-industrial societies.¹⁷⁶

Strömberg¹⁷⁷ has used the concept of proto-industrialization in a study of iron production in Halland, Skåne and Småland in the period of Danish rule.

171 Hovland, Nordvik and Tveite (1982) 45–56; Hutchison (2003) 9, with refs.

172 Clarkson (1985); Ogilvie and Cerman (1996) 7–11.

173 Ogilvie (1996) 33–34.

174 Ogilvie and Cerman (1996) with articles.

175 Schlumbohm (1996) 17, 22.

176 Schlumbohm (1996) 16.

177 Strömberg (2008).

He considers a long time span and sees development from self-sufficient production to the production of goods intended for the Danish market. This development adheres to the criteria for the situation described above, from domestic production close to the home via minor surplus production undertaken in the vicinity of the raw materials to a final phase in which large-scale production is sited according to the source of energy and is practised using what are known as 'timber-clad furnaces'.¹⁷⁸ This is a bloomery furnace that produces by the direct method, but its size, extent, the use of bellows and so the higher yield, means that this business has features in common with the first Swedish blast furnaces. It should be noted here that, in Swedish literature, the term 'timber-clad foundries'¹⁷⁹ is also used of the first blast furnaces. Crucial to the latter phase is the fact that the production is considered as the production of a surplus for Denmark up until the Peace of Roskilde of 1658.

Strömberg uses Clarkson's criteria about how widely proto-industrial production was undertaken, and considers them to be matched by the archaeological evidence.¹⁸⁰ The farmers were involved in specialized surplus production; a certain form of commodity production was being practised; iron was produced for an external market, namely the Danish mainland; and a network which links ironmaking sites and the farms with the coastal trading sites and landing places developed. Strömberg thus makes use of several principles of proto-industrialization, but has departed from the strong definition concerning, amongst other things, home production and the chronological framework. In this way, he follows Schlumbohm's ideas about industrialization before industrialization in order to describe an economic-historical event. To put it another way, he makes use of the concept of *proto-industrial character* in order to describe the economic significance of iron production in a given period.

A further central factor for Strömberg is how this phase of production came into being. In order to answer this question, he has made use of a hypothesis formulated by the historians Andres Florén and Göran Rydén. Their view is that the early industrial phase is marked by capitalist production becoming more and more normal. The reason for this is that there were changes in the relations of power in production, with the household losing its place as the production unit. The changes are related to roles, and to the distribution of roles, such as who fetches the raw materials, who decides where and when production is to take place, who controls the product, and so on. Possible consequences of this change are that on the one hand there may be a master or

¹⁷⁸ In Swedish, *mulltimmarugnar*; Strömberg (2008) 138–139.

¹⁷⁹ *Mulltimmarhyttan*.

¹⁸⁰ Strömberg (2008) 146–149.

a group with the right to govern production, while on the other there may be capital-rich factory owners with full control over production. Between these extremes there can be a multitude of forms of production and a range of relevant agents. The development from one status to another, they suppose, could take place by a new agent or group getting hold of the 'secret' (technological) knowledge, i.e. the cultural capital. Another way in which differentiation could be effected is when it came to the distribution of the resources for production, such as who should have access to technology, raw materials or the product.¹⁸¹ A change in the economic system, from a self-sufficient domestic practice to a more commercial business, directed by new knowledge or the channelling of knowledge, is thus the possible explanation that Strömberg perceives as the basis for the change towards proto-industrial activity.

Proto-industrialization is, however, by definition only a transitional stage on the road towards complete industrialization. It is a link in a chain and thus no natural end-point. If proto-industrialization nonetheless does not proceed to the next phase, a contrary development has to take place, something that Clarkson¹⁸² defines as 'de-industrialization'. She notes a number of reasons why such a regression should take place. A central circumstance is that areas with rich labour resources may hinder the development of technology, something that leads to a failure in competition. A development in the direction of de-industrialization can also happen in the case of the loss of external markets. This may be caused by competition and cheaper goods, but also by the disappearance of the needs of the customers. Internal and external political development, change in social structures, and a decline in access to resources and raw materials are other causal factors. In many cases it is a combination of various factors that together leads to de-industrialization rather than industrialization. Strömberg¹⁸³ observes such a process in Danish southern Sweden. The reason why the iron production collapsed, he believes, was war, with the consequent loss of social organization, a ruined economic structure, and lost know-how.

As I see it, in a broad view, proto-industrialization can be conjoined with the economic structure that I have developed in discussion this chapter. It is my opinion, therefore, that proto-industry can be a fruitful economic model helping us to understand the development of pre-industrial bloomery ironmaking in my study area. Its origins, development, history and demise are all events

181 Florén and Rydén (1992) 3–5.

182 Clarkson (1985) 34–38.

183 Strömberg (2008) 31.

that can be explained as elements of the model. Before the economic development can be put into context, however, an account must be given of a series of studies that combine to lead to the conclusions. In the following chapter, I shall begin by placing the material analysed in the context of the history of such research.

Research Backdrop

The past 15–20 years have seen a series of historiographical reviews of research into Norwegian bloomery ironmaking.¹ Only a brief summary, principally aimed at pointing out the relevant research and publications, will be given here. The focus is on forms of production, where chronology and typology of furnaces is afforded particular significance. Charcoal pits and roasting places are also considered in detail, as these elements in combination are vital to the arguments later in the book.

Status of Research

Research into *jernvinna* in Norway is a tradition more than a hundred years old, and several individuals have made important contributions to the mapping out and accumulation of knowledge of the field. Up to around 1960 it was natural scientists, or local and regional specialists, who were responsible for the accumulation of information.² A number of archaeological scholars also discussed this topic, such as A.W. Brøgger³ and Hougen,⁴ but it was only from the end of the 1960s that archaeologists really started to participate in research. Martens's work at Møsstrand⁵ was a pioneering example. Also central were A.B. Johansen's studies from the Hardangervidda Project.⁶ With the economic development of the hydroelectric power plant and other social projects, ancient monuments associated with *jernvinna* were also discovered in ever greater quantities, and research into *jernvinna* thus flourished from the 1980s (Fig. 2.1). This is the background to the publication of a series of studies dealing with large parts of southern Norway.⁷

1 Narmo (1996a); Rundberget (2002a); Bjørnstad (2003); Stenvik (2003); Espelund (2005); Tveiten (2005); Loftsgarden (2007); Larsen (2009).

2 E.g. Kleiven (1912); Olafsen (1916); Holme (1920); Brøgger (1925); Falck-Muus (1927); Hauge (1946); Undås (1961).

3 Brøgger (1925).

4 Hougen (1947).

5 Martens (1988).

6 Johansen (1973).

7 See Larsen (2009) with refs.

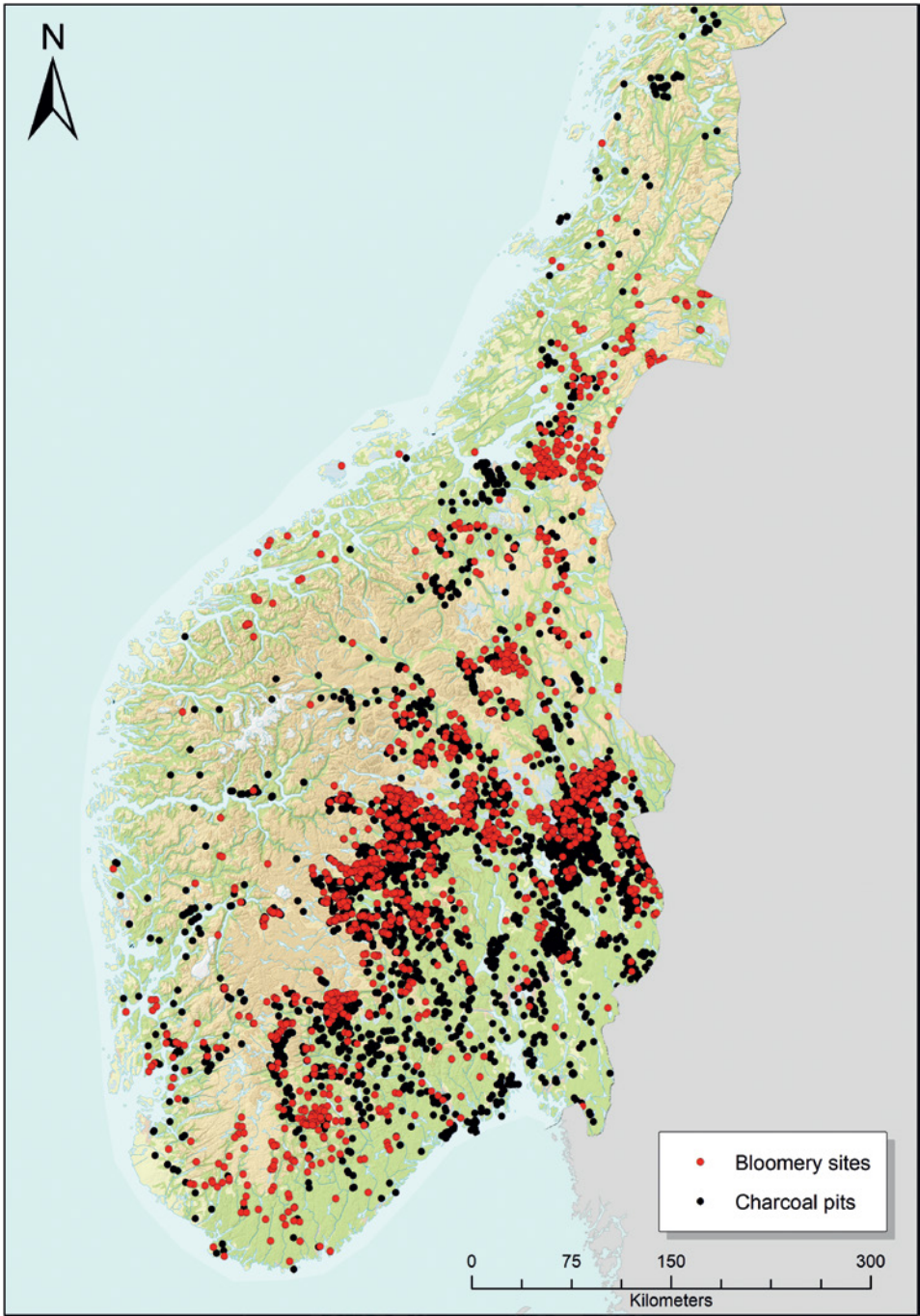


FIGURE 2.1 *Recorded bloomery sites and charcoal pits in southern and central Norway, following Askeladden, 1 May 2012*
MAP: B. RUNDBERGET, MCH

The Introduction of Iron and *Jernvinna*

Knowledge of the extraction of iron is understood to have originated in the Hettite kingdom in the eastern part of Anatolia towards the end of the 2nd millennium BC. The south-eastern parts of Europe put this knowledge to use around 1000 BC and it then spread gradually out across the whole of Europe over the next 500 years.⁸ In Norway, *jernvinna* can certainly be traced back to the latest centuries BC. Some analyses of stratified iron slag in the rich agricultural land along the River Glomma reveal a phase of production with earlier radiocarbon dates going back to c. 400 BC.⁹ I believe, however that we need to be cautious about taking the Norwegian tradition of *jernvinna* so far back in time, not least when considering the ‘time-with’ of the pine wood, and the wide probability ranges in age BP in some cases (see Ch. 5). New research, incorporating detailed analyses of wood species¹⁰ will probably produce a clearer picture of early dated contexts like these (see Ch. 9).

Although there are some early traces, little research has been focused upon how iron production became known and subsequently established itself as a common technology. This has been more closely examined in Denmark¹¹ and especially in Sweden.¹² In addition to iron bloomeries and finds of slag, iron finds from Bronze Age graves and other contexts are crucial to these studies. Access to and the use of iron in jewellery, tools and weaponry have been decisive in interpretations of its introduction to specific areas.¹³ But this does not tell us anything about when the introduction of bloomery ironmaking got underway, as the material was presumably imported to begin with. Essential for the study of the introduction of *jernvinna* has been, consequently, the examination of the relationship between other metallurgical activity, especially bronze casting, and iron production. The earliest finds of iron slag have been made in association with bronze casting, and crucibles and moulds have reciprocally been found at ironmaking sites.¹⁴ This association in the evidence has led to two different theories in Sweden. One of them proposes that the bronze

8 E.g. Pleiner (1980); Zimmermann (1998).

9 Melvold and Berg-Hansen (2008) 16–18; Sæther and Nybruget (2011) 60–66; Simonsen and Bukkemoen (2014).

10 Loftsgarden et al. (2013).

11 Levinsen (1983); Nørbach (1998); Olesen (2010).

12 Hansson (1989); Hjärthner-Holdar (1993); Magnusson and Rubensson (2001); Wranning (2004); (2012); see also Zimmermann (1998).

13 Pleiner (1969); Levinsen (1983); Hjärthner-Holdar (1993).

14 Hjärthner-Holdar (1993); Wranning (2004).

smiths themselves developed iron production, amongst other things through a network of contacts with counterparts in Europe.¹⁵ Against this stands the hypothesis that it was new groups within the population together with a new dominant elite who introduced iron production and made it common to the majority of people.¹⁶ No similar studies have been undertaken in Norway, but dating both of artefacts and iron bloomeries appears to suggest contemporaneity of introduction over much of Scandinavia.

Methods of Production in Chronological Terms

Bloomery ironmaking in Norway is securely dated back as far as 300–200 BC. For two thousand years, right up to the nineteenth century, iron was extracted according to more or less the same principle. Bog ore was used, and the process of ironmaking took place in a clay furnace according to the direct method. The essential technological principles were unaltered. There are nonetheless differences in operation which testify to development. Three main lines can be distinguished, and these form the typological structure that is primarily followed in Norway today. For much of the Early Iron Age, here referred to as Phase I, smelting was undertaken by digging a pit beneath the clay shaft that formed the reduction zone in which the liquid slag was collected. This type of furnace has therefore been christened the *slag pit furnace*. From the absence of evidence for charcoal it is inferred that the earliest *jernvinna* was undertaken using the wood itself. Whether or not this was common practice has not, however, been discussed,¹⁷ but charcoal has been found at some bloomery sites in eastern Norway. The situation remains unclear.

Three main traditions of furnace type can be distinguished¹⁸ (Fig. 2.2). The *Trøndelag furnace* has a distribution centred in the interior of Trøndelag¹⁹ and has also been found in Jämtland.²⁰ A few examples of the type have been identified in Agder.²¹

The *Østland furnace* was first identified through the Dokkfløy investigations at the end of the 1980s, hence the name associated with eastern Norway. The

15 Hjärthner-Holdar (1993); Magnusson and Rubensson (2001).

16 Wranning (2012).

17 Larsen and Rundberget (2014).

18 Rundberget (2008); Larsen and Rundberget (2009).

19 E.g. Farbrege et al. (1985); Stenvik (1991b), (1996); Prestvold (1999); Rundberget (2002a).

20 Magnusson (1986).

21 Kallhovd and Larsen (2006) 237–253.

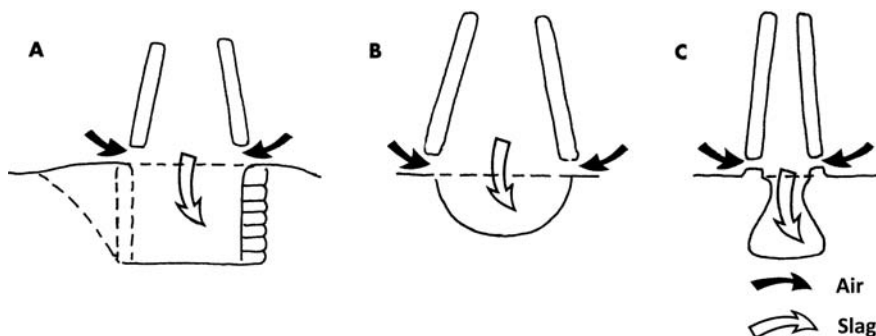


FIGURE 2.2 *Typological scheme of known varieties of shaft furnaces with a slag pit, after Espelund (2005) 87*

type has since been found over much of southern Norway, from the interior of eastern Norway²² over to parts of the west.²³

The final principal type, the *Eg furnace*, has clear Continental parallels, and is perhaps best known from Jutland in Denmark,²⁴ and not least from the Świętokrzyskie (Holy Cross) Mountains in Poland.²⁵ This type of furnace is smaller than the other two, and it is a single-use furnace with a new pit dug for each firing. In the other traditions it was normal practice to empty and reuse the slag pits. This type of furnace is best known from Eg in Kristianstad, in Rogaland, together with a number of sites in the counties of Agder and Telemark, at Løten and Åker in Hedmark County, as well as in Valdres in Oppland County.²⁶

In the period AD 500–700, this method gradually disappeared and a new technology, labelled Phase II, was introduced. This type of furnace is called the *slag tapping furnace*. This new technology was in use from c. AD 800 to 1400.²⁷ The slag tapping furnace was fired with ready-made charcoal and the

²² Espelund (2005) 117; Larsen (2003) 90–92.

²³ Bjørnstad (2003) 63.

²⁴ Voss (1995a) 132–139; Pleiner (2000) 70.

²⁵ Bielenin (1976).

²⁶ Bloch-Nakkerud and Schaller (1979); Haavaldsen (1997); Larsen (2003) 176–183, (2009); Risbøl (1997) 7–23; Bårdseng (1998) 14–15; the furnace in Valdres was excavated in 2014 and is not yet published.

²⁷ E.g. Espelund (1991) 71–99, (2005) 119–146; Larsen (1991); Stenvik (1991b) 414–415; Narmo (1996a) 8–14.

charcoal pits are therefore to be seen as linked to this change in the process of ironmaking.²⁸

The Phase III furnace is most familiar in Norway as the *Evenstad furnace*,²⁹ following a description by the sheriff Ole Evenstad from 1782. This type of furnace is chronologically primarily post-Reformation, although Espelund³⁰ suggests that dating indicates it could have been introduced as early as the fourteenth century. The Evenstad furnace is described as having been fired with dried pine wood, and radiocarbon dates are very difficult to assess. The bulk of the dates have a median point before AD 1600, but the technique is best documented in the eighteenth century, which would lead us to expect several dates from this period. There is a question mark, then, over the correctness of the inference that this practice was going on as early as the fourteenth century.³¹ The same type of furnace in Sweden, where it is called the stone-walled furnace, is believed to have been in use as early as the thirteenth century.³² The main area of the Evenstad furnace is Østerdalen north of the village Koppang, but it has also been identified in Trøndelag, at Voss in Hordaland County, and at Hol in Buskerud County.³³

Research of recent years shows that the three-stage chronological scheme is probably overly rigid, and that the chronology of furnaces should not be applied slavishly.³⁴ At the Rødsmoen site, several furnaces of the slag pit type are dated to the period AD 540–1275.³⁵ Beside Hurdal church in Hurdal Municipality, a slag pit furnace dated to AD 1050–1270 has been excavated.³⁶ In Jämtland in Sweden, slag pit furnaces become most common in the period AD 400–600, but are suggested to have remained in use right through to the eleventh century.³⁷ This is also the case in Dalarna.³⁸ The dates of the Jämtland furnaces have been debated, and the evidence for such late production of this style is questioned.³⁹

28 Narmo (1997) 16–19, 111; Rundberget (2008) 22.

29 Espelund (1997).

30 Espelund (2005).

31 Larsen (2004) 159.

32 Magnusson (1994); Englund (2002).

33 Espelund (2005) 140–141.

34 Narmo (1997) 28.

35 Narmo (1997) 115–116.

36 Bergstøl (2002).

37 Magnusson (1986) 173.

38 Serning (1973); Hyenstrand (1974).

39 Johansen (2003) 30–33.

The Slag Tapping Furnace in Europe and Scandinavia

Furnaces with slag pits and slag tapping furnaces are the most common methods of direct iron production in Europe. Both of these, however, are umbrella terms covering innumerable varieties. A third category is what is known as the *flag-lined bowl furnace*. The terminology of furnaces has been discussed both in Europe⁴⁰ and in Scandinavia, where several attempts have been made at classifying on the basis of a range of proposed categories.⁴¹ These suggested classifications have subsequently been criticized for not being chronologically determined, for being idealized and distorted, and for being inadequate because of their incompleteness.⁴² In Norway, there has been an important debate about the possible presence of the bowl furnace.⁴³ Narmo has discussed the problem of these furnaces at Møsstrond, and concluded that these cannot be bowl furnaces as Martens had decided. He believes, alternatively, that the cists with no openings in the walls are smithing sites, while those with wall openings were slag tapping furnaces,⁴⁴ and that the bowl furnace has not been found in Norway. Espelund has more recently interpreted the cists as furnaces for the preparation of the ore.⁴⁵ This theory is disputed, and has no support in the archaeological evidence. Through recent survey in the development zone at Lake Møsvatn, several new furnaces have been discovered, some of which have bricks of slag and others flowing slag.⁴⁶ In most recent years, furnaces of this type have also been excavated at Fillefjell⁴⁷ and Øyer⁴⁸ in Oppland County, as well as at Hovden in Aust-Agder County. All of these are dated to the Merovingian Period, but the technology varies. From the types of slag at Øyer and Hovden the furnaces are to be identified as slag tapping furnaces. At Fillefjell, the furnaces with small, stone-lined pits are interpreted as both slag pit furnaces⁴⁹ and slag tapping furnaces.⁵⁰ With these new discoveries, the bowl-furnace theory has to be regarded as dead in Norway. Similar debates have gone on in Europe too, and the seeds of doubt have been sown there over

40 E.g. Coghlan (1956) 86–106; Cleere (1972) 8–23; Tylecote (1986), (1987); Pleiner (2000).

41 Martens (1978) with comments; Serning (1979); Magnusson (1986).

42 Clough (1986); Narmo (1996a); Englund (2002).

43 Martens (1978), (1988).

44 Narmo (1996a) 10–12.

45 Espelund (2009a) 68; Espelund and Johannessen (2005).

46 Risbøl (1999).

47 Mjærum (2006); Tveiten (2012).

48 Berge and Larsen (2011).

49 Mjærum (2006).

50 Tveiten (2012).

the identification of bowl furnaces, suggesting that the features are rather remains of collapsed shaft furnaces.⁵¹

From this discussion, Narmo⁵² has simplified the classificational scheme to encompass only the two main types described above, in the chronological sequence:

- Slag pit furnaces
- Slag tapping furnaces

This chronological sequence holds for Scandinavia. In Europe we find large slag tapping furnaces contemporary with slag pit furnaces, for instance in the large-scale Roman ironmaking at Ferrum Noricum (Hüttenberg, Austria) which employed slag tapping furnaces⁵³ (Fig. 2.3).

Espelund too has produced a chronologically determined system of classification. In this, the slag pit furnace is subdivided into two types, the Trøndelag furnace and the Østland furnace. He does not, on the other hand, recognize



FIGURE 2.3 *Tapping slag in the form of a fan from roman slag tapping furnaces at Ferrum Noricum, Hüttenberg, Austria*

PHOTO: B. RUNDBERGET, MCH

⁵¹ Tylecote (1981) 21.

⁵² Narmo (1996a).

⁵³ Cech (2008).

the Eg furnace as a distinct type as he considers this form to have been found only at a few sites. Both finds and distribution, however, do show that this type is relatively common, and the furnace has to be defined as a type in parity with the Trøndelag and Østland furnaces.

In his classification system, Espelund includes the Evenstad furnace as a third type.⁵⁴ In contrast to Narmo, who classifies the Evenstand furnace as a slag pit furnace,⁵⁵ Espelund considers that this furnace should be described as a *sunken furnace without slag tapping*.⁵⁶ This is because there is no slag pit in the normal sense of the term and because the iron and the slag cannot be separated before the smith takes the product out of the furnace.⁵⁷

Englund has also discussed the classification of furnaces.⁵⁸ In contrast to Narmo and Espelund, he comes to the view that a generalization into two main types means that all of the variants within each emerge as a uniform and defined group. The solution is not to label all of the furnaces that have been excavated by, for instance, the site name, as this would lead to an uncontrolled plethora of types. At the same time, site-name designations could also lead to the generalization of whole regions. In the case of Norway, I too have argued that one has to discuss the above-mentioned Østland and Trøndelag furnaces in a new light, as new evidence shows that the distribution pattern is more complicated than was formerly supposed.⁵⁹ Furnace types should rather, in Englund's opinion, be distinguished according to several factors on the basis of both fundamental and individual characteristics such as shaft type, air supply and slag collection.⁶⁰ In doing so, it appears to me that Englund reverts some way to the earlier classifications without using their terminology directly. What is new is his attempt to generate a discussion (a description and an interpretation) of typology in the context of both excavation and research. The typology should not be used merely to pigeonhole the various furnaces.⁶¹

Englund's point is an important one, but in a broad discussion of slag tapping furnaces with a wide geographical perspective it is not possible to go into great depth on all particular features. I believe, therefore, that it is sensible to use the general term *slag tapping furnace* as the basic one in this study.

54 Espelund (2005) 146.

55 Narmo (1996a) 9.

56 Narmo (1997).

57 Espelund (2009a) 70.

58 Englund (2002) 227–259.

59 Rundberget (2008) 25; Larsen and Rundberget (2009).

60 Englund (2002) 252.

61 Englund (2002) 258, tab. 7.

Slag Tapping Furnaces in Europe

Slag tapping furnaces were in use over much of Europe for a long time. The earliest furnaces appear by the third century AD, while the most recent that have been identified in northern Europe go out of use in the fifteenth century. The prehistorian Radomir Pleiner labelled this type as *shaft furnaces* and divided the group into three sub-types on the basis of their structure.⁶² Note that I also use the term *slag tapping furnace* for this type:

- *Small thin-walled free-standing shaft furnaces* could easily be repaired when damaged. This type of furnace is thought to have been advantageous in areas where the producers moved the sites of production to follow the sources. The type is best known for small-scale production, but has also been found in large-scale enterprises. Most examples are known from central Europe (Czech Republic, Hungary and Germany) and east towards Russia and Ukraine.
- *Thin-walled stone- or timber-embanked shaft furnaces*. These furnaces could be constructed higher than the thin-walled type above. Both free-standing furnaces and furnaces built into to natural terraces or butted up to constructed walls occur. In the British Isles, this type of furnace was standard in the Roman Period. From the seventh century to around AD 1200 it appears in central Europe and especially in Hungary.
- *Thick-walled shaft furnaces* may be either free-standing or built into banks of soil. The heavy structure means that the furnaces last longer and can be used for several seasons. Thick walls with external insulation also increase productivity. This type of furnace is found primarily in areas of intensive iron production. Both the construction and repairs required a lot of labour. The shafts could be constructed of stone or clay. In most cases bellows were used. This type of furnace is found mainly in southern and western Europe (France, Austria, Switzerland and western Germany). An example from the last centuries BC with a height of up to 2 m has been identified at Martys in southern France.⁶³ A similar example is reported from Hüttenberg-Feisterweise in Austria.⁶⁴ The slag from these furnaces has what is described as the form of a fan⁶⁵ (Fig. 2.3). From around AD 700, a smaller form with a height of 0.65–1.5 m appears. The internal diameter of these furnaces is 35–50 cm and the shaft walls are up to 40 cm thick. A sort of average furnace

62 Pleiner (2000) 172–188, for comparison see also Tylecote (1987) 151–178.

63 Domergue (1998).

64 Cech (2008).

65 Pleiner (2000) 262–263, Fig. 70.1 and 2.

of this category is the slag tapping furnace at Sonnerscheid, Sauern, West Germany.⁶⁶ This furnace is dated to AD 1200–1400 and had an internal diameter of 45 cm and box-like walls of 40–45 cm with an internal clay lining. The height of the furnace was preserved up to 0.60 m but it was estimated that it had been 1.5 m. The tapping hole was located immediately above the bowl-shaped hearth. The air supply was at a right angle to the tapping hole.⁶⁷ The distribution on the Continent is largely the same as that of the earlier type, but in this period it occurs in the Baltic area too⁶⁸ and in mainland Scandinavia. The furnaces at Møsstrand and Dokkfløy⁶⁹ are included here, although their thick shaft includes stone slabs.⁷⁰

As I see it, there are great differences between the tradition of western Europe and what we find over much of Norway. This is particularly the case in respect of the question over free-standing shafts contrasted with those with external insulation. In this context, Pleiner's discussion⁷¹ of the eastern slag tapping furnaces which show greater similarities to the Norwegian tradition is interesting. As early as the fourth and fifth centuries, at Opole in southern Poland, furnaces appear with an external wooden casing and stone and earth. Similar forms with external stone walls are found in Bohemia and around the Baltic too.

Slag Tapping Furnaces in Denmark

Slag tapping furnaces have not yet been identified directly in Denmark. The only evidence that indicates production in this type of furnace so far is finds of tapping slag.⁷² Bloomery ironmaking was located primarily in what have in more recent times been intensively farmed areas. As iron production with the slag tapping technology was carried out at ground level, most of its traces will now have been destroyed and removed. Only six or seven production sites have been identified, on the evidence of waste heaps. Five are in Jutland (one of them immediately to the south of the German border) and one on Fyn.⁷³ Two sites are dated. A slag heap at Jels Skov in southern Jutland proves to have been in use in the period AD 1030–1220. An ironmaking site/smithy at Vattrup that

66 Sönnecken (1971) 20–23.

67 Sönnecken (1971) 20.

68 Peets (2003) 127–128.

69 Martens (1988); Larsen (1991); Narmo (1996a).

70 Pleiner (2000) 186.

71 Pleiner (2000) 187–188.

72 Voss (1995b) 27–35; Lyngstrøm (2008) 30–33.

73 Voss (1995b) 28.

was excavated by the archaeologist Niels Nielsen in the 1920s has subsequently been dated to AD 1290–1405.⁷⁴ A possible slag tapping furnace has also been excavated at Tæbring on Mors by the archaeologist Olfert Voss and the scientist Arne Jouttijärvi. This furnace is dated to the eighth century but the results have not yet been published.⁷⁵

Skåne and Halland have to be included in Danish medieval iron production.⁷⁶ In Halland, a number of ironmaking sites from the Late Middle Ages and into the seventeenth century are known at Vittsjö.⁷⁷ Only one of these was a slag tapping furnace. Otherwise, a large version of the sunken shaft furnace (like the Evenstad type) was used.⁷⁸ The slag tapping furnace is the earliest dated structure in the area, from AD 1030–1310,⁷⁹ and it is identified as this type from the finds of flowing slag.

Several slag tapping furnaces were investigated in the course of the Tvååker Project, also in Halland.⁸⁰ These furnaces are of the paired furnace type (see Ch. 2, Slag tapping shaft furnaces in Sweden)⁸¹ and the structure of the furnaces has clear similarities with the medieval furnaces at Dokkfløy.⁸² The dates are earlier than those at Vittsjö (AD 1000–1300) and correspond closely with the Norwegian slag tapping technology. Slag tapping shaft furnaces have also been found in Skåne on several occasions, albeit of a rather different form there;⁸³ the Linneröd furnace in Vedby is a good example. This was first studied by the archaeologist John Nihlén in the 1930s.⁸⁴ A more recent examination was undertaken by Englund.⁸⁵ The furnace type is a variant of the slag tapping furnace in which the part of the shaft that is the actual reduction zone is sunk into the ground. The furnace also differs in not having been lined with clay; clay is used only as filling between the stones. The slag shows that some of it was tapped, but most of the slag was cleaned out of the furnace. Strömberg has looked at a number of medieval furnaces in the Halland-Skåne region and

74 Voss (1995b) 31; see Nielsen 1924.

75 Pers. comm. Jens Jørgen Olesen, 19 March 2012; Arne Jouttijärvi, 23 March 2012.

76 Strömberg (2008).

77 Ödman (2001).

78 Nilsson (1981); Englund (1994a), (1994b).

79 Ödman (2001) 74.

80 Strömberg (2004); Buchwald (2004); Magnusson (2004).

81 Englund (2002) 245–247.

82 Magnusson (2004) 208–209.

83 Englund (1994b).

84 Nihlén (1939).

85 Nihlén (1939) 80–84.

shows that they are very similar to one another but that they differ from the Swedish slag tapping furnaces in having a square base.⁸⁶

Slag Tapping Shaft Furnaces in Sweden

In Sweden, it is principally in the south-west that the slag tapping shaft furnace is known. Halland and Skåne have already been discussed. Other core areas are Västergötland⁸⁷ and Småland.⁸⁸ Also further north, in the western part of Västerdalarne⁸⁹ and in north-eastern Värmland,⁹⁰ slag tapping technology has been identified at a number of sites.

Characteristic of south-western Sweden is what are known as paired furnaces. Three areas stand out with this technique:⁹¹ Lerdala and Vättlösa in Skaraborgs län, Åsamon and Azamon in Småland and Tranemo and Örsås in Kind. Through Englund's excavations at Tranemo and Örsås, the form and type of the furnace have been clearly revealed. The structure Tranemo 266 is a good example, consisting of a paired furnace close to a 'croissant-shaped' slag heap. The furnaces are typically small, clay-lined, slag tapping shaft furnaces. The interior measure of the furnaces examined ranged from 25 to 40 cm, and their height is inferred to have been around 80 cm. They may have flared out a little from the base to the top. The furnaces were built inside a stone casing on three sides. The tapping was done on the fourth side. The slag channels were narrow, 10–20 cm at the widest, close to the furnace, and the slag took the form of thin strings. The investigations could not definitively determine where the bellows were positioned.⁹² A furnace of this type has also been examined at Axamo in Småland.⁹³ This consisted of 10 cm of a clay shaft with an outer stone wall of stone slabs. Outside it was found a layer of sand which was used to insulate the furnace. The sand is thought to have been held in place by a wooden casing. The internal diameter of the shaft was 30–40 cm and its height is estimated to have been 80 cm. Each furnace had one slag heap. The furnace structure at Hedenstorp has been graphically reconstructed⁹⁴ (Fig. 2.4). In Älgårå and the Skara area similar furnaces have been investigated, but these are not described

86 Strömberg (2008) 82–103.

87 Millberg (1985) 27; Englund (2002) 169–205.

88 Nordman (1994); Karlsson (2001); Englund and Grandin (2002); Magnusson (2010b).

89 Carlsson et al. (1999).

90 Svensson (1998); Myrdal-Runebjer (1999).

91 Englund (1994a) 7.

92 Englund (2002) 189–197.

93 Englund and Grandin (2002).

94 Englund and Grandin (2002) Fig. 21; Lorentzon (2008).

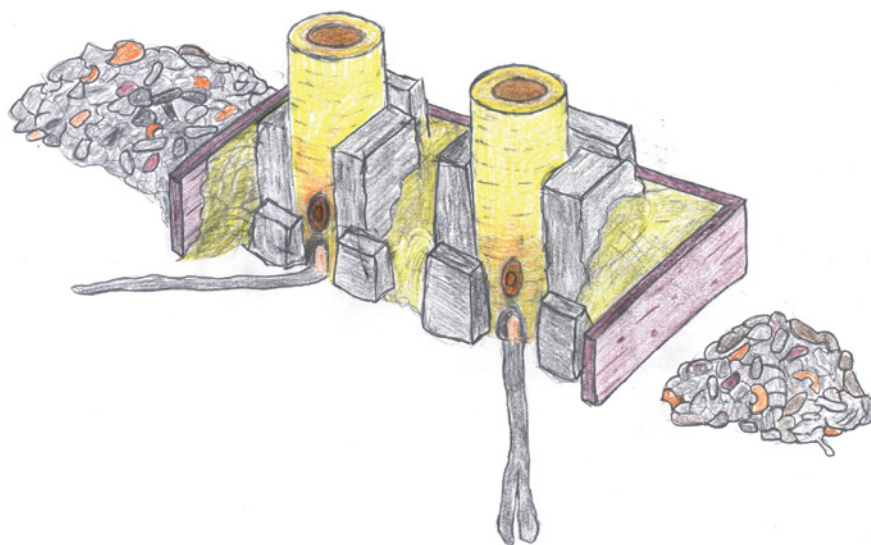


FIGURE 2.4 *Reconstruction of a double furnace excavated at Hedenstorp in Axamo, Småland, after Englund and Grandin (2002) 2, Fig. 21*

as paired furnaces. Unlike at Tranemo and Axamo, the slag is also tapped out into pits on the outside of the furnace.⁹⁵

While the paired furnaces appear to have been a common phenomenon, individual slag tapping shaft furnaces have been identified on a smaller scale. The furnaces in Halland and Skåne have been noted. In Lima and Transtrand in Dalarne, surveys for economic mapping in 1973–75 identified iron bloomeries with slag tapping.⁹⁶ In the southern part of Lima, by Ofors and Tandö, several ironmaking sites have been found of a type with no visible furnace. During the excavation of a bloomery site south of Västre Tandö, furnaces of both the Middle Ages and more recent times were discovered.⁹⁷ The latest furnace was a classic, dry-walled furnace with clay-lining, with parallels with the Evenstad tradition. Beneath parts of a slag heap a cut feature was found that proved to be part of an earlier furnace. The depth of the pit was 30–35 cm. At the top level there was a scorched clay layer of 10 cm. In the pit itself lay a basal bowl with wooden impressions on the outer sides of the bottom.⁹⁸ In the slag heap were several large pieces of tapped slag. The slag had the shape of a fan and is of the slag cone type (see Ch. 3, Bloomery ironmaking in the Gråfjell area). One

95 Magnusson and Millberg (1981), (1983); Millberg (1985).

96 Carlsson et al. (1999).

97 Carlsson et al. (1999) 198–210.

98 Carlsson et al. (1999) 202, Fig. 7, 206.

of the slag cones had clay burnt on to one side. The form was concave and the slag cone was interpreted as having been formed against the convex exterior of the furnace.⁹⁹ The interpretation of this furnace is that it bears similarities to Early Iron Age furnaces in Trøndelag and Jämtland.¹⁰⁰ This conclusion is based, in my judgement, on incorrect premises, as those are slag pit shaft furnaces, not slag tapping ones. At the same time, their period of use was several centuries earlier than the furnace at Västresand. The view is, nonetheless, unsurprising as the furnace had a pit characteristic of the slag pits of the Early Iron Age. It was, however, dated to the Early Middle Ages, and as I see it there are clear parallels to *jernvinna* in Hedmark. In addition to Lima, this type of furnace may have been found in the Leksand district¹⁰¹ and, as I shall discuss further in a later chapter, the furnace type also occurs in the border area between Värmland and Norway.

Iron bloomery sites with the slag tapping technology in Sweden are dated mainly to the late Viking Period and the first part of the Middle Ages. Many sites appear to have been in use around AD 1200. From the Skara area there are 40 radiocarbon dates in the period AD 900–1200.¹⁰² Englund's investigations at Tranemo show that the technology using paired furnaces probably continued to AD 1350.¹⁰³ The smelting furnace in the south of Lima has the same dating, AD 950–1280.¹⁰⁴

Slag Tapping Shaft Furnaces in Norway

Within Scandinavia, the slag tapping shaft furnace is definitely best represented in Norway. There are known examples from Bodø in Nordland and there is secure evidence for the type as far south as Hovden and the Setersdal heaths (Fig 2.5).

Northern Norway

In North Norway, there are only three known bloomery sites, of which one is medieval.¹⁰⁵ This is beside Lake Rognli in Bodø Municipality and consists of three small slag heaps and two charcoal pits. One of the slag heaps and both the charcoal pits are dated to the thirteenth century. The site has not been

99 Carlsson et al. (1999) 207, Fig. 19.

100 Carlsson et al. (1999) 209.

101 Syse (1996).

102 Magnusson and Millberg (1983) 87.

103 Englund (2002) 189.

104 Carlsson et al. (1999) 224.

105 Jørgensen (2010) 45–49.



FIGURE 2.5 *Places mentioned in the text*
MAP: B. RUNDBERGET, MCH

excavated and the furnace type is therefore unknown. From the type of slag and its quantity, it is deduced to have been a slag pit shaft furnace and not the tapping type as one would have expected.¹⁰⁶ If this is correct, the furnace is unique in Norwegian terms, as this technology had gone out of use several centuries earlier.

Trøndelag

In Trøndelag, studies of ironmaking are focused primarily on the earliest *jernvinna*, and medieval production has received only limited attention. The reason for this is partly the difficulties in identifying slag heaps of this period.¹⁰⁷ The slag tapping furnace is rare in Nord-Trøndelag County, although a number of sites have been found in the long valleys of Sør-Trøndelag County.¹⁰⁸ There have only been five excavations. At Håen in Melhus Municipality two furnaces are interpreted as slag tapping shaft furnaces. Both were small, clay-lined furnaces of 40–50 cm diameter with external insulation of stone slabs. Håen I, which was the better preserved, was sunk some 30 cm into the ground, and immediately outside it there was a slag tapping pit. The slag, with a concave base, also shows signs of having been tapped into a pit. A pit 80 cm north-east of the furnace is suggested perhaps to have been the location of the bellows. Håen I has two dates for the period AD 650–850. The dates for a charcoal layer at Håen III indicate a period of use of AD 1050–1230 while the furnace itself is dated to AD 1280–1410.¹⁰⁹

At Storbekken in Budalen, Midtre Gauldal Municipality, 200 m from an Early Iron Age site of the Trøndelag type, a production site has been investigated in which the slag heap is dated to AD 1020–1220.¹¹⁰ At the top of a knoll the remains of two furnaces were found. These were extremely poorly preserved, but they had been walled with stone and clay. They had slag tapping. The slag heap was sited below the furnaces and had been partly covered by bog.¹¹¹

In Hendalen, also in Midtre Gauldal, a damaged ironmaking site was examined by Stenvik and Espelund in 1994.¹¹² The furnace was built out of stone slabs and boulders with an internally clay-lined shaft. A large quantity of stone indicates that the furnace had been a tall one, but it was not possible to prove

106 Jørgensen (2010) 68.

107 Stenvik (1990) 214.

108 Rundberget (2002a); Stenvik (in prep.).

109 Stenvik (1987).

110 Espelund and Stenvik (1993) 123.

111 Stenvik (1989).

112 Stenvik (in prep.).

this. The lower part of the clay shaft was still standing, and its internal diameter was measured at around 40 cm. It was a slag tapping furnace, but it is not reported where and how this was done. East of the furnace is a pit that is suggested to have been the base for bellows. A charcoal sample from the slag heap is dated to AD 1010–1165.

A further site has been excavated at Stavsjøen in Malvik Municipality.¹¹³ Water extraction from the lake was followed by finds of slag on the shoreline. A slag heap was partially excavated because of the danger of it collapsing. Some of the slag had a clear flow structure while other were base slag. The flowing slag is inferred to have been tapped out into a pit outside the furnace. Three dates from the slag heap show a period of use of AD 900–1190. A higher point in the terrain proved to have been a neatly walled furnace with an internal clay lining. It is suggested that there may have been an external wooden casing outside the stone wall. The internal diameter is only 25 cm and the surviving height is 80 cm.

Finally, a slag tapping shaft furnace has been excavated in Bymarka, just outside the city of Trondheim.¹¹⁴ The furnace was constructed of stone and clay. The slag type and the siting of the furnace above the ground level confirms its type. From the spread of slag in the area it is inferred that there were more furnaces in the vicinity.¹¹⁵ The furnace, ore and charcoal stacks are dated to the end of the Viking Period, AD 885–1025.

Western Norway

Along the coast from Møre og Romsdal County down to Rogaland County, the slag tapping shaft furnace is only sporadically represented. One furnace was identified during the excavation of the building ruin at Nordre Valldalseter as part of the archaeological work in the valleys of Røldal and Suldal river systems.¹¹⁶ Remains of the base of a furnace were found beneath the hearth of the building. Martens¹¹⁷ interpreted this as a free-standing slag tapping shaft furnace with an internal diameter of 46 cm. The furnace is dated to AD 1080–1190. The archaeologist Ragnar Bjørnstad¹¹⁸ emphasizes that the structure must have been damaged when the later building was constructed and used, and that there had been a stone structure around the clay shaft.

¹¹³ Stenvik (in prep.).

¹¹⁴ Sætre (2006) 215–218; Berge (2009) 113–115.

¹¹⁵ Sætre (2006) 215–216.

¹¹⁶ Næss (1964).

¹¹⁷ Martens (1988) 76.

¹¹⁸ Bjørnstad (2003) 70.

Apart from the furnace at Valldalseter, only two iron bloomeries of this type have been excavated in western Norway. These were excavated at Buhaugene on the western side of Fillefjell in Lærdal, Sogn og Fjordane County, in 2007.¹¹⁹ The type of furnace has several points of similarity with the Dokkfløy furnaces (see below) but there is a difference in the outer insulation, which consists partly of stone slabs, partly of boulders, and partly of earth.¹²⁰

Besides the excavated sites, individual sites have been recorded in Skrubbdalen and Liabaret in Eidfjord, Hordaland County. The former consists of three slag heaps with a typical flowing character. Two charcoal samples from one slag heap are dated AD 1280±50 (T-5885).¹²¹ In the valley Sysendalen on the western side of Hardangervidda, there have also been identified three bloomery sheds, nine ironmaking sites and two slag heaps that are dated to the Iron Age and the Middle Ages. Finds of slag and a roasting place have also been recorded in Seljestand in Odda Municipality.

In Sogndal Municipality, an iron bloomery site from the end of the Viking Period has been recorded in Øvstedalen. The site comprises a furnace, a slag dump and two piles of charcoal. Another bloomery site has been identified from a collection of slag close to a charcoal pit. In Møre og Romsdal County, Tveiten¹²² has found flowing slag at two bloomery sites, one in Nasset (AD 970–1110) and one in Surnadal (AD 675–775). Apart from these, there are no definite traces of this tradition in this area.

In Rogaland, the archaeologist Per Haavaldsen¹²³ used slag typology to determine furnace types, and concluded that 22 of 45 known sites could be associated with the tapping technology. These sites are distributed right across Rogaland. Two ironmaking sites have been investigated and dated to the Viking Period and the Middle Ages.

Southern and Eastern Norway

In the southeast of Norway, a large number of bloomery sites of the Viking Period and the Middle Ages have been recorded and studied. I cannot discuss all of the investigated sites as that would swamp the present project. But, as I find there are clear parallels in furnace technology within the region, a thorough review is unnecessary. A selection of the central areas of iron production in southern and eastern Norway will be presented here.

¹¹⁹ Tveiten and Simpson (2008); Tveiten (2012).

¹²⁰ Tveiten and Simpson (2008) 51.

¹²¹ Bjørnstad (2003) 52.

¹²² Tveiten (2005) 33.

¹²³ Haavaldsen (1997) 70–71.

In Agder, *jernvinna* of the Middle Ages is best documented at Hovden in Bykle Municipality, Aust-Agder County.¹²⁴ The bloomery sites are densely packed, and Martens¹²⁵ has calculated a frequency as high as five sites per square kilometre. The bulk of the production sites have flowing slag. The archaeologist Perry Rolfsen¹²⁶ describes the furnaces as slag tapping shaft furnaces with a diameter of 35–45 cm. On three sides the shaft is encased by stones standing on edge, and turf, soil and smaller stones are packed between the stone casing and the shaft. The slag was tapped out on the side that was not encased. Martens also notes stones placed on edge that may have been part of the furnace structure.¹²⁷

Two iron-extraction sites were examined in 2006.¹²⁸ During the fieldwork at the site Godstøylbekken, a well-preserved furnace 40 cm high and with an interior diameter of 35 cm was discovered. The furnace had an outer shell of stone slabs on three sides. It was open towards the production area both for the bellows and for tapping out (Fig. 2.6). The other excavations provided supplementary evidence confirming the details of the furnace at Godstøylbekken. Subsequently, a further eight sites were excavated. All consisted of bloomery sheds with one or more chambers. These furnaces were of the same type. The technology and organization in this region seem to be consistent.

The first major studies of *jernvinna* in Norway were carried out at Møsstrand alongside Lake Møsvatn in Telemark County.¹²⁹ The research covered 19 iron-extraction sites where, in addition to the stone containers noted, clay furnaces that Martens defined as shaft furnaces were excavated. Seventeen furnaces from ten sites were excavated and the results provided much of the basis for the development of Martens's already noted typological scheme.¹³⁰ In the main report of 1988 this typological scheme was not used; Martens then describes the clay furnaces at Møsstrand rather as free-standing shaft furnaces which were partly sunk into the ground. On two or three sides of the outer side of the clay shaft were stones placed on edge and partly dug into the ground. Several furnaces also have a layer of boulders or slabs around the edge stones. The clay shaft was round or oval with an internal width of 30–50 cm. The height of the shaft is inferred to have been just 50 cm, which is low in comparison with

124 Martens (1982); Bloch-Nakkerud (1987); Rolfsen (1992a) 79–88; Mjærum (2011).

125 Martens (1982).

126 Rolfsen (1992a) 82.

127 Martens (1988) 76.

128 Mjærum (2011).

129 Martens (1978); Martens (1988).

130 Martens (1978).

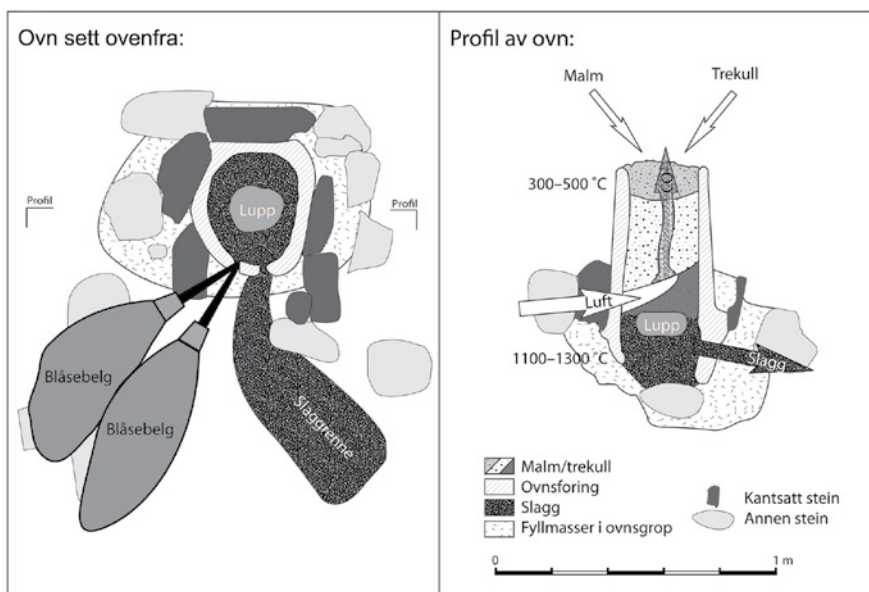


FIGURE 2.6 Reconstruction drawing of iron production furnaces at Hovden: schematic drawing of a furnace with slag channel, based on one of the furnaces at Godstøylbekken. The iron formation took place in a clay shaft, at least 0.7 m high and approximately 0.4 m across. The furnace was heated to 1100–1300 °C to remove the slag. Ventilation was provided through one or two bellows. The unworked iron (bloom) gathered in the lower section of the furnace while the slag was drained through the side
DRAWN BY A. MJÆRUM, MCH

other areas. From the furnaces there was a constructed channel for the flow of slag, and flowing slag has been found *in situ*. How the draught was provided is uncertain, but one part of a 24-cm shaft has the tuyère in place. The opening measures 4 cm and was at least 9 cm above the base of the furnace.

In Buskerud County, the best information on the tradition is from Haglebu in Sigdal.¹³¹ Two sites were fully excavated in advance of a tourist development. Only the lower parts of slag tapping furnaces were preserved. A round clay shaft was surrounded by stone slabs placed on edge. Production was undertaken in a shed with one or more chambers.

In his dissertation on *jernvinna* east and west of the mountains Langfjella, Tveiten¹³² has undertaken minor excavations of seven sites in Sudndalslia at the end of Hallingdalen. The scale of the investigations means that the information gained is variable. The ironmaking site which was best documented

131 Grøtberg (2007).

132 (2012) 61–130.

comprised a bloomery shed with two chambers, one of which is interpreted as the production area and the other as dwelling quarters and a preparation chamber. In all, three furnaces were identified, two of which were in concurrent use. The furnaces are thought to have been of the type that has been found in excavations in southern Norway west of Gudbrandsdalen, and the slag is of the flowing slag type.¹³³ One further bloomery site was investigated in 2011, and the picture here is the same.

Apart from these excavations, only minor investigations have been undertaken. Surveys in the upper areas of Buskerud County indicate that the tradition was more or less the same, but there are probably minor variations with respect to the construction and insulation of the clay shafts.

There are several areas of Oppland where thorough studies have been made. I make particular note of Dokkfloy.¹³⁴ Other areas in Oppland where important excavations have been carried out are Beitostølen¹³⁵ and Fillefjell.¹³⁶ Beside Lake Dokkfloy several well-preserved slag tapping shaft furnaces have been excavated, and their morphology emerges clearly. Best preserved was a furnace which had been covered by heaps of slag and soil after use. It was a round shaft furnace, surviving to a height of 70 cm and with an interior diameter of 35 cm. A break at the top of the shaft shows that this had been a bit taller. In some places the shaft wall consists of several layers of clay, which is pointing to a long time use and reuse of the furnaces through the season. The shaft was set within a framework of slate slabs, and between the shaft and the casing was a filling of soil, clay and smaller stones. A slag channel led out from the furnace¹³⁷ (Fig. 2.7). This furnace is the type specimen of the Dokkfloy Type, and Narmo has studied the furnaces from four bloomery sites in relation to it, to identify five common denominators:¹³⁸ (1) sunk or dug into a slope or constructed within an artificial mound of earth and stone; (2) low paving constructed up to the cut into the 'edge of the slope'; (3) a casing of slate slabs set on edge; (4) a shaft of coarsely tempered 'clay'; (5) a slag channel. The structural elements are selected for their properties. Slate slabs are more heat-resistant than normal stone as they are laminated and can tolerate the stress of heating and cooling. The stones are preserved on three sides while on the front only remains of slabs are found. The height of the slabs was 20–35 cm. The furnaces

¹³³ Tveiten (2012) 71–88, 186–187.

¹³⁴ Jakobsen et al. (1988); Larsen (1989), (1991); Narmo (1996a).

¹³⁵ Omeland (2000); Larsen (2005); Mjærsum (2007).

¹³⁶ Larsen (2009); Tveiten (2012).

¹³⁷ Larsen (1991) 149.

¹³⁸ Narmo (1996a) 69–80.



FIGURE 2.7 *Slag tapping shaft furnace at DR 36 in Dokkføy, Gausdal Vestfjell, Oppland. The furnace was found in a slag heap and is the best preserved slag tapping furnace that has been excavated in Norway. The shaft was 0.7 m in height. It was made of clay and was insulated with stone slabs*
 PHOTO: M. THORLEIFSEN, MCH

were dug into a slope and the top of the slabs set on edge was level with the ground surface. At the front edge, the bottom level of the slabs was at the same height as the floor of the furnace house. The slag was tapped out into one of the side slabs and the draught was supplied through the opposite side slab.

Before the Rødsmo Project, only one medieval furnace had been excavated in Hedmark. At the Hallbekken site at Skotterud in Eidskog Municipality, a furnace was placed in a shallow hollow in the ground. The furnace consisted of a poorly preserved clay shaft measuring 30 x 20 cm internally. A slag channel was found, and in the slag heap there was both flowing slag and slag that is described as having flowed vertically down and formed slag lumps¹³⁹ (Fig 2.8). The furnace is dated to AD 1020–1155 (Masca) (calibrated, IntCal09: cal AD 900–1153).

At Rødsmoen, a total of seven ironmaking sites have been investigated. Both slag pit furnaces of the Early Iron Age and slag tapping furnaces was excavated. In several cases, sites were interpreted as having different furnace types. As well as describing the slag tapping furnaces, I shall discuss the slag pit furnaces, as these are crucial to the study.

The slag pit furnace at Rødsmoen is smaller than the typical Østland furnace. The mouth of the pit measures 60 cm and it is 30 cm deep. Inside, by the

¹³⁹ Martens (1980), (1988) 76.



FIGURE 2.8 *The isolation pit beneath the smelting furnace excavated at Hallbekken, Skotterud in Eidskog*
 PHOTO: I. MARTENS, MCH

sides of the pit, there is a lining of staves, and the interior diameter of the pit is around 30 cm. From slag with impressions of wood it is inferred that sticks were also placed vertically within the pit. This was to facilitate the removal of the slag after production. No shaft was found, but the footprint showed that this had a greater diameter than the pit itself. From the shaft there is a shallow gradient down into the pit. The thickness of the clay shaft was around 4 cm and the shafts are thought to have been insulated using an outer wooden casing with a layer of sand or soil between the casing and the shaft. The dimensions of the shaft must be related to the use of wood in production. The slag pit furnaces are dated to AD 540–1275, and, according to Narmo, continued throughout the period of transition from Phase I to Phase II. He therefore regards the technique of collecting slag in a pit as concurrent with slag tapping.¹⁴⁰

The slag tapping furnace is thought, from the archaeological evidence, to be very poorly preserved at Rødsmoen. The explanation of this can be found in a hypothesis concerning the foundations of this type of furnace. The furnace structure is consequently inferred from the distribution of slag, the morphology of slag, and fragments of shafts. The characteristic tapping cone shows that the slag that flowed out of the furnace was tapped from a certain height. At site R695, no pits were found in the area where the furnaces are thought to have been, and it was considered as a result that this furnace was raised up some way above ground level. Stone was not used as part of the structure. For this reason,

140 Narmo (1997) 112–118.

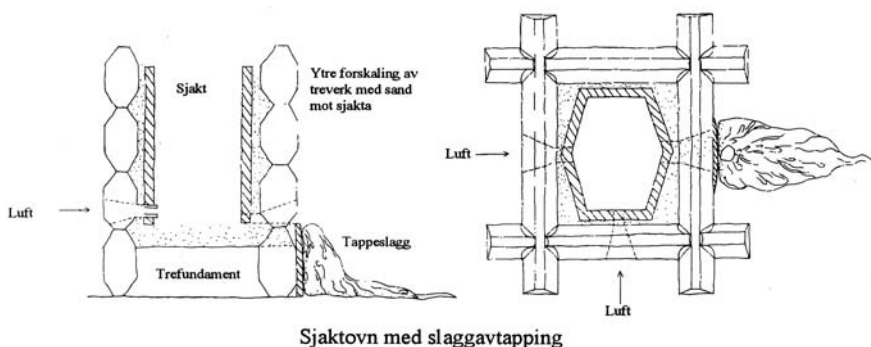


FIGURE 2.9 Interpretation of a slag tapping shaft furnace at Rødsmoen, after L.E. Narmo 1997:113, Fig. 69, MCH

it is thought that the structure consisted of a cogged wooden casing that was packed with sand. Above the sand layer, a clay shaft of six clay plates was constructed. Externally, the shaft was insulated with sand within the wooden casing. The draught and tapping were taken care of through a channel and outside the wooden casing. Clay was also used on the outside of the wooden structure to prevent it catching fire (Fig 2.9). The form and structural details of the shaft have been inferred from finds of flat clay fragments.¹⁴¹ After the excavations, R695 was treated as a type standard for ironmaking in this part of the country, and has been used as a reference point in later surveys in Hedmark, including those in the Gråfjell area (see Ch. 3, Bloomery ironmaking in the Gråfjell area).

Features of the Development and Diffusion of the Slag Tapping Shaft Furnace

'Slag tapping technology' is simply an umbrella term covering innumerable greater or lesser variations which range over a wide geographical area and a long period of time. All the same, there are many definite parallels. The tapping technology of the Roman Period thus has many characteristics in common with the furnaces of the Middle Ages even though the trend was for the types of furnace to become smaller, a feature that is also seen in the transition from the slag pit technology to slag tapping in Norway. The process, the methods of insulation or isolation, and the use of materials, meanwhile, are elements that recur in every era.

This complicated picture means that it is difficult to say anything definite about the development of the method and its paths of diffusion. Some lines can be discerned nonetheless. Thin-walled tapping furnaces have been

¹⁴¹ Narmo (1997) 113, Fig. 69.

identified in the British Isles in the Early Iron Age, but they are mainly distributed in central and Eastern Europe in the Later Iron Age and the Middle Ages. Thick-walled furnaces are, by contrast, concentrated in southern and western Europe. Pleiner, meanwhile, has defined the Dokkfløy furnace as a minor variant of this type. To some extent, the distribution respects the boundary between the Roman Empire and Germania, but, except for iron extraction in the British Isles, tapping technology in the north is later than that in the south, and it is the slag pit tradition that is dominant on the northern Continent in the Roman Iron Age. Different methods may thus have their roots in different cultural traditions.

It was first in the Later Iron Age that the tapping technology, undertaken in thin-walled furnaces, spread across the north, and particularly the north-east, of the Continent. One question, as a result, is whether the Dokkfløy and Møsstrond furnaces are to be classified as thick-walled. As noted, Pleiner treats the sand fill and stone slabs as part of the shafts—which I regard as a mistaken view in terms of the classificational criteria he takes as fundamental. The furnace itself should rather be said to have a thin clay shaft, albeit with an external foundation, which puts the type in the group of *thin-walled shaft furnaces with an external reinforcement*. In terms of distribution too, this is also more logical as it is this type of furnace that appears in Great Britain in the Roman Period and over much of central Europe from the seventh century. Quite realistically, I therefore consider that the understanding of furnace technology we find at Dokkfløy, Møsstrond and also in southern Sweden had its origins in this zone, although I cannot immediately specify exactly where, from the current state of research. One hint, however, is the fact that the tapping technology accompanies charcoal-making in pits. The charcoal pit method is rare in the British Isles and in north-west Europe but is widely distributed in east-central Europe and the Baltic (see Ch. 2, Distribution and organization of slag tapping shaft furnaces), which may point to a more north-easterly origin.

Investigations of tapping technology show that furnaces over much of southern and central Norway are very similar to the Dokkfløy furnaces, both in structure and size, and in process. Most of the time, the furnace technology seems to maintain near uniformity, and the thin-walled shaft furnace with external reinforcement is therefore, in my view, a standard for the tapping technology, albeit with variants in terms of foundations, diameter and tapping. However, one area stands out from this norm. The excavations at Rødsmoen demonstrated that in this region a different method reigned. The investigations in Eidskog and the Gråfjell area confirmed this,¹⁴² and this technological fact is one of the principal subjects for discussion in the present book.

142 Martens (1980); Rundberget (2007).

*The Distribution and Organization of Slag Tapping Shaft Furnaces
in South-eastern Norway*

The distribution of the technology in south-eastern Norway in the Viking Period and the Middle Ages has been discussed by several scholars.¹⁴³ Figure 2.1 shows the location of all bloomery sites in southern and central Norway. The map includes sites from the Early Iron Age, as it is virtually impossible to distinguish these with certainty in the survey reports. After a preliminary review of the survey records, I infer that production sites from the late Viking Period and the Middle Ages make up a figure of well over 90%, even though in some regions, such as Nord-Trøndelag, central Agder and Snertingdal in Oppland, it is production of the Early Iron Age that is dominant.¹⁴⁴ As Early Iron Age production was also sited nearer to the settled districts, i.e. it is found lower down in the valleys and in the lower-lying lands, it is relatively easy to produce a picture of the distribution in the Middle Ages. Another feature that confirms the Viking Period and medieval distribution is the charcoal pits. These are included in the map, although one distributional problem is the fact that charcoal pits associated with smithing also appear here. These are particularly located close to the settled districts, and along the coast and along watercourses such as the River Glomma, in areas where there was no extensive iron extraction. The picture is therefore a bit muddled, but when we are clear about these factors it is possible to discern distinct patterns in the distribution. As Narmo puts it,¹⁴⁵ it is obvious, therefore, that the medieval bloomery ironmaking ran in a belt across eastern Norway, from Hovden in Bykle in the south to Åmot in Hedmark in the east (Fig. 2.1). Narmo also points out that the belt probably continues into Trysil and across the Swedish border. This location has a natural explanation in the raw materials required. An increase of production and the continuous expansion of settlements and agriculture in the lower-lying areas led to production being shifted to areas of outlying land. A general trend, therefore, in the Viking Period and the Middle Ages is that the majority of sites were established in higher, forested districts and lower-lying mountain ranges.¹⁴⁶ *Jernvinna* came to have a much wider distribution in the landscape, between about 400 and 1100 m ASL. The medieval bloomery sites in Hedmark are found rather lower down, in typical conifer woodland areas up to

143 Martens (1988), Narmo (2000), Larsen and Rundberget (2009) and Larsen (2009), amongst others.

144 Larsen and Rundberget (2014).

145 Narmo (2000) 139.

146 Larsen and Rundberget (2009).

700 m ASL, while production is otherwise principally found in what is now the birch belt between 750 and 1100 m ASL.

Despite great similarities in position, *jernvinna* appears in various configurations. Narmo¹⁴⁷ has identified three known forms of organization: the Møsvatn tradition, the JKS tradition and the Hedmark tradition. In addition, he uses a possible fourth tradition in the area between the JKS (Oppland County) and Møsvatn (Telemark County) traditions. His arguments are based upon the state of knowledge as far as 2000, considering types of site, the type and size of slag heaps, furnace-types and furnace buildings, as well as the organization and form of the charcoal pits.¹⁴⁸ Since then, however, several excavations have been carried out which rather diverge from this picture. One phenomenon, for instance, is that *jernvinna* at Tyinkrysset in the north-west of Oppland to a large extent closely matches Dokkfloy. In his doctoral thesis, Tveiten¹⁴⁹ has revealed that *jernvinna* in his two study areas, Fillefjell and Sudndalen, is organized in various ways, creating two different regions. Through selective studies of eight ironmaking sites in the study area, Tveiten has mapped the distribution in this region. He believes that *jernvinna* in Valdres shows clear parallels to the JKS tradition, while many of the sites in Hallingdal reflect an organization with furnace and slag heap associated with a single charcoal pit.¹⁵⁰ A special feature he has discovered is that sites on the western side of Langfjella are not the same as *jernvinna* on the eastern side of the mountains, but conversely are more similar to Valdres and the inner Hardanger area.

Charcoal Burning, Spatially and Temporally

A charcoal pit is defined as *a pit meant for the production of charcoal*. A charcoal pit usually has a circular or square hollow surrounded by a bank consisting of the upcast, although there are both oval and rectangular pits. The technology is dated from c. AD 800. The wood was burnt to charcoal in the pits. These pits are normally about 3–6 m in interior diameter, and as much as 1.2 m deep. The wood was piled up as parallel or crossed sticks, and covered up before ignition.

The charcoal pits are almost exclusively linked to production in slag tapping shaft furnaces and with smithing, and in Norway they are the predecessors of the charcoal kilns that were in use well into the twentieth century. The newer

147 Narmo (2000) 140.

148 Narmo (2000) 138–149.

149 Tveiten (2012) 242.

150 Tveiten (2012) 242–254.

charcoal kilns are of two different types, horizontal and vertical, the former of which structurally has most in common with the charcoal pits. The horizontal kilns are also thought to be the earliest in Norway, and to be derived directly from the charcoal-pit tradition.¹⁵¹ The vertical kilns, meanwhile, represent a method that was employed across much of Europe from as early as the Middle Ages. In England, there is documentary evidence of kiln-burning from the late thirteenth century.¹⁵² The Norwegian vertical kiln tradition, however, is believed to have been introduced from Germany and Sweden in the sixteenth and seventeenth centuries, and to be linked to the inception of the Norwegian mining industry.

Charcoal Pits in a European View

Charcoal pits are found widely in the southern part of the Scandinavian Peninsula.¹⁵³ They are also found in parts of northern and central Europe, such as Poland,¹⁵⁴ Estonia,¹⁵⁵ the Netherlands¹⁵⁶ and Austria.¹⁵⁷

In Europe, the use of charcoal can be traced back to the Bronze Age, and it is described in both Greek and Roman texts.¹⁵⁸ Vanoccio Biringuccio describes the burning of charcoal in a pit as an alternative to kiln-burning as late as 1540¹⁵⁹ (Fig. 2.10). Here, a charcoal pit is referred to as a pit with a diameter of one and a half *braccia*, which means about 90 cm.¹⁶⁰ The depth of the pit was about the same as the diameter, and the purpose was to produce charcoal for smithing. Biringuccio considered that this method was not suited to metal production as it produced charcoal which did not burn as well as charcoal produced in an *appagliaro* (a kiln like a haystack). Biringuccio's type of charcoal pit has been found in several parts of Europe, including Austria (*Meilergarbe*), where the tradition is dated both to the Migration Period and early in the

¹⁵¹ Narmo (1997).

¹⁵² Hart (1968); Kelley (1986) 9–11.

¹⁵³ E.g. Undås (1961); Hyenstrand (1972); Bloch-Nakkerud (1987); Englund (1994a); Persson (1996); Narmo (1996b); Carlsson et al. (1999); Larsen (2004); Damlien and Rundberget (2007).

¹⁵⁴ Bielenin (1976).

¹⁵⁵ Peets (1987), (2003).

¹⁵⁶ Pers. comm.. Patrice de Rijk, 12 September 2008.

¹⁵⁷ Klemm et al. (2005).

¹⁵⁸ Kelley (1986) 3–4; Pleiner (2000) 119.

¹⁵⁹ Biringuccio (1540 [2005]) Ch. 3.10 [178–179].

¹⁶⁰ The *braccio* is an Italian *ell* [Norw. *alen*], which measures c. 595 mm; *braccia* is the plural.



FIGURE 2.10 *Charcoal pit drawn by V. Biringuccio (1540 [2005])*

Middle Ages.¹⁶¹ A charcoal pit of a similar type was also described in Bohuslän in Sweden during the First World War.¹⁶²

On the basis of Biringuccio's descriptions, Pleiner refers to this as the charcoal pit proper, while the type that is dominant in northern Europe is referred to as a sunken charcoal kiln because the tradition has so many similarities to the horizontal kilns. Pleiner makes things difficult, however, when he treats Englund's excavated charcoal pits in Kind as charcoal pits, while in the case of Narmo's dissertation on Dokkfløy he decides that these should go under the heading of sunken kilns.¹⁶³ Despite Pleiner's suggested definitions, I think it is appropriate not to replace the well-known term *charcoal pit* for 'our' charcoal-making tradition. In the English translation I judge, therefore, that the term 'charcoal pit' is to be preferred, rather than 'charcoal kiln': a term that is used for the charcoal pit tradition, but which is also the label for the kiln tradition as a whole.

The Norwegian Charcoal Pit Tradition

The link between the charcoal pits and metalworking is an early one. Charcoal pits and charcoal-making are referred to as early as in Old Icelandic laws

161 Pertelweiser (1970); Klemm et al. (2005).

162 Lindner (1922) 368–369.

163 Pleiner (2000) 121–124.

and sagas,¹⁶⁴ but are not there directly associated with ironmaking. In Norway, charcoal pits are referred to together with bloomery sites in Trysil Municipality.¹⁶⁵ At the inception of research into *jernvinna* in Norway early in the twentieth century, the farmer, author and politician Ivar Kleiven¹⁶⁶ observed the relationship between iron furnace and charcoal pit, where he believed the charcoal was supplementarily used in order to reach a higher temperature. Charcoal pits are associated with *jernvinna* in several early works, but these are consistently uncertain about whether the charcoal pits really were linked to iron extraction.¹⁶⁷ Falck-Muus¹⁶⁸ later decided that the charcoal pits were directly related, but only to the earliest production. In all later major studies the charcoal pits are included as an element of *jernvinna*, but the focus on the charcoal pits as ancient monuments has, with a single exception,¹⁶⁹ found little place in scholarship.¹⁷⁰

Since the 1980s, charcoal pits have been examined, especially in the south-east of Norway. Larsen¹⁷¹ has reviewed the most important excavations of charcoal pits up to 2008 in an academic programme of research into *jernvinna*. Information on charcoal pits and charcoal burning in other parts of Norway is significantly scarcer.

In northern Norway a more substantial study of charcoal pits on Vestvågøy in Lofoten has been carried out.¹⁷² Altogether 201 charcoal pits were recorded, but no signs of iron production have been found. Large fields of charcoal pits with a high volume of output are associated with ironmaking all the same, while smaller clusters and lower volumes are considered to have been linked to smithing. Exploratory excavations were undertaken in six charcoal pits at Kjelhusåsen in Harstad Municipality. The charcoal pits were circular and had banks, but only three had layers of charcoal.¹⁷³ Two charcoal pits that were close to the iron bloomery site by Lake Rognli have been excavated and dated. Another has been excavated in Vefsn Municipality, Nordland County.¹⁷⁴ Charcoal pits have also been excavated and dated at the bloomery site at

164 Bloch-Nakkerud (1987) 61–63 and refs.

165 Smith (1784 [1966]) 17.

166 Kleiven (1912) 329.

167 Olafsen (1916) 23; Holme (1920) 55; Falck-Muus (1927) 359.

168 Falck-Muus (1931) 57–58.

169 Undås (1961).

170 Hauge (1946) 33–36; Johansen (1973); Martens (1988) 16.

171 Larsen (2009).

172 Johansen (2000).

173 Holm-Olsen (1988) 93–94.

174 Pers. comm. Birgitta Berglund, 31 August 2009.

Hemmetstad in Kvæfjord Municipality. The site is from the pre-Roman Iron Age, and one charcoal pit has a similar date.¹⁷⁵ This piece of information is important in showing that charcoal-making in a pit was known that early.

In Trøndelag too, strikingly few charcoal pits have been recorded, and those that have been identified are small compared with those of southern Norway. It can be difficult to locate them as a result.¹⁷⁶ The centre of activity is in Sør-Trøndelag County, with the municipalities of Trondheim, Oppdal and Klæbu standing out.¹⁷⁷ Charcoal pits associated with *jernvinna* have been described in the Gauldalen valley,¹⁷⁸ but there is otherwise rather a mismatch between the bloomery ironmaking of the Late Iron Age and the Middle Ages and the distribution of charcoal pits.¹⁷⁹ The archaeologist Ragnhild Berge¹⁸⁰ has recorded about 150 charcoal pits in the forest Bymarka beside the city of Trondheim. Eight of them are dated. Half are dated to the period c. AD 1000–1200 and the other half to the fourteenth century. Only one bloomery site has been identified and excavated in Bymarka, and this is earlier. The charcoal-burning is consequently inferred to have been associated with activity in the nearby medieval town of Nidaros.

Likewise, in Møre og Romsdal County there are few recorded charcoal pits.¹⁸¹ At Veøy in Romsdal, the archaeologist Britt Solli¹⁸² excavated one charcoal pit. The charcoal pits are small and circular, similar to those in Trøndelag. Iron production has not been identified and the pits are, in consequence, associated with smithing. In western Norway, charcoal pits are more widespread, but not in the quantity found in the south-east. The archaeologist Svein Indrelid¹⁸³ has written about the finding of charcoal pits in the Flåmsfjella mountains. During survey work in parts of the Sysendalen valley, 128 charcoal pits were identified. A considerable number of charcoal pits have also been recorded in Odda. In both places, the charcoal pits were found in association with bloomery sites. In Rogaland County, charcoal pits have been identified over much of the region, some in association with bloomery sites, others not.¹⁸⁴

175 Jørgensen (2010) 33–37.

176 Sauvage (2005); Berge (2009).

177 Berge (2009) 124–129.

178 Lodgaard (1962) 328.

179 Berge (2009) 128.

180 Berge (2009) 114.

181 Tveiten (2005) 53.

182 Solli (1996) 99–101.

183 Indrelid (1988) 108–110.

184 Haavaldsen (1997).

Charcoal Pits in South-eastern Norway—Typology and Location

Charcoal pits are the most common type of visible ancient monument in the outlying areas of south-eastern Norway. They are sometimes found along the coast, but the distribution is primarily from the immediate edge of the farmed land out to peripheral forest and mountain environments. The form of the charcoal pits is partially geographically governed, and clearly reflects variant traditions. In south-eastern Norway, the rule appears to have been that square charcoal pits were an easterly characteristic while those west of the line from Lake Mjøsa to Gudbrandsdalen are mostly round.¹⁸⁵ This should, however, be described as a rule with exceptions. In Hedmark, hardly any round pits have been identified south of Stor-Elvdal. West of Mjøsa, meanwhile, there are charcoal pits of all forms, although the circular type predominates.¹⁸⁶ Square charcoal pits have been examined in the valleys of Gudbrandsdalen, Valdres and Hallingdalen, and at Hovden. From Trøndelag northwards there are both round and square charcoal pits. The circular form is predominant in Trøndelag¹⁸⁷ while in northern Norway the majority are rectangular.¹⁸⁸

The Charcoal Pit Chronology

Information on the chronology of the charcoal pits has long been an unmet need. The archaeologist Thomas Persson¹⁸⁹ has discussed their age, and points out dated charcoal pits of the Roman Iron Age both in Sweden and Denmark. The charcoal pits of the pre-Roman Iron Age at Hemmestad in northern Norway that have been referred to are, to date, the only examples securely dated before the Late Iron Age in Norway. These pits are described as small and shallow, 0.5 to 1.3 m in diameter and 10–35 cm deep.¹⁹⁰ Such small pits can be difficult to find, and they may have largely been destroyed, since charcoal-making for smithing and for much of the bloomery ironmaking in the Early Iron Age was located in zones close to the settled districts where much of the land has since been taken for agriculture.

Falck-Muus attempted to date charcoal pits when he drew a distinction between the wood-fired Evenstad tradition and prehistoric iron production for which the energy source was charcoal. This distinction is partly true, but he didn't realize that wood could be used in the earliest bloomery ironmaking

185 Narmo (2000) 140; Damlien and Rundberget (2007).

186 Larsen (2004) 152–153.

187 Sauvage (2005); Berge (2009).

188 Johansen (2000).

189 Persson (1996) 32.

190 Jørgensen (2010) 33.

practice too.¹⁹¹ It would seem that this state of affairs did not fit into his notion of an evolutionary development from the primitive to a steadily more efficient and improved furnace.¹⁹²

Charcoal pits in Norway were radiocarbon-dated for the first time under the Hardangervidda project.¹⁹³ All were functioning in the Middle Ages, with the earliest dating at cal AD 1020–1270.¹⁹⁴ Despite this, A.B. Johansen attributed the charcoal pits at the site Fet in Sysendal to the ironmaking site which has dates from the Early Iron Age. Martens dated one charcoal pit at Møsstrand. This was calibrated to cal AD 1020±80 (Masca) (recalibrated, IntCalog: cal AD 998–1165). The charcoal pit lay beside an ironmaking site considered to be of the earliest type (AD 500–800), but it is not noted to what extent she links the site and the charcoal pit together for any reason other than their proximity. During the survey of the Atna watercourse at the end of the 1970s, several charcoal pits were identified which were attributed to the Evenstad tradition.¹⁹⁵ Although at this time dates for archaeological finds were beginning to appear more frequently, all three cases reveal a lack of appreciation of the charcoal pits' context as late as the 1970s.

At Hovden, the dating to the Late Iron Age and the Middle Ages was confirmed by 28 charcoal pits that are dated to AD 900–1400.¹⁹⁶ More recent investigations in the same area have corroborated this.¹⁹⁷ Larsen¹⁹⁸ has looked at 308 dates from many parts of south-eastern Norway, and, although a few dates go back to the Merovingian Period, he judges that the main period of use is closely congruent with Hovden, and the peak lies in the thirteenth century.

Of the charcoal pits that were examined on Vestvågøy, the square examples are the earliest, dated to AD 1100–1350. The set labelled Rectangular I belong to an intermediary phase, AD 1350–1450, and Rectangular II are dated to the period AD 1450–1700. Two further charcoal pits in Harstad are dated to AD 1265±65 and AD 1290±60 (Masca).¹⁹⁹ Although these cannot be directly linked to iron production, it is interesting that the dates here too agree well with southern Norway, with the exception of the rectangular pits, which can be attributed to

191 E.g. Stenvik (1991a); Narmo (1996a); Espelund (2005); Larsen and Rundberget (2009).

192 Rundberget (2002a).

193 Johansen (1973).

194 Johansen (1974).

195 Mikkelsen (1980).

196 Bloch-Nakkerud (1987).

197 Mjærum (2011).

198 Larsen (2004).

199 Holm-Olsen (1988) 94, age BP not given.

the transitional phase between the charcoal pit and the horizontal kiln tradition.²⁰⁰ The charcoal pit in Vefsn is dated post-AD 1655.²⁰¹

The charcoal pits on Veøy in Romsdal appear to be rather more recent. Six samples have an earlier limit at AD 1230–1445. Only one of these belongs chronologically before AD 1290, calibrated to AD 1230–1370, while one lies within the fifteenth century, AD 1410–1445.²⁰² Through the major bloomery ironmaking projects, it also became clear that the charcoal pits have an association with the slag tapping shaft furnace. A problem is that the slag tapping shaft furnace appears somewhat earlier than the charcoal pits.²⁰³ Since, however, many of the dates are derived from pine, it is believed that the shift in technology should be brought up towards AD 800.²⁰⁴ On that basis, charcoal pits are able to indicate the expansion of Viking Period and medieval ironmaking into areas where no actual production sites have been discovered.

Bog Ore and Roasting Places

Ore-formation and the Detection of Bog Ore

In the Norwegian *jernvinna*, bog ore was used almost exclusively. It is not possible to exclude the possibility that sea ore was used, however, as was the case in Sweden.²⁰⁵ Iron ore is formed in bogs, but there are several preconditions for precipitation to take place. First of all, there has to be a source: bedrock or mineral soil. It is also necessary to have continually percolating or running water for movement. Also fundamental are biological processes such as the uptake of nutrients and micro-organisms which break down the floral remains. Groundwater contains greatly reduced iron (Fe^{2+}). This is formed by the breakdown of bedrock through bacteria using up all the oxygen during the decomposition of the floral remains in layers of humus and bog. The iron moves with the seeping water out into the ground water. The reduced iron is oxidized to Fe^{3+} through contact with the air and is then precipitated as rust or bog ore (iron hydroxide: $\text{Fe}(\text{OH})_3$).²⁰⁶ Bogs with what is needed for ore-formation are known as *soligenous* or *hillside bogs*. Soligenous bogs are shallow and fixed,

200 G.A. Johansen (2000) 87.

201 Pers. comm. Birgitta Berglund, 31 August 2009.

202 Solli (1996) 100–101.

203 Narmo (1997).

204 Larsen (2004) 158.

205 Pettersson (1982); Englund (2002); Strömberg (2008).

206 Rueslätten (1985) 31–38.

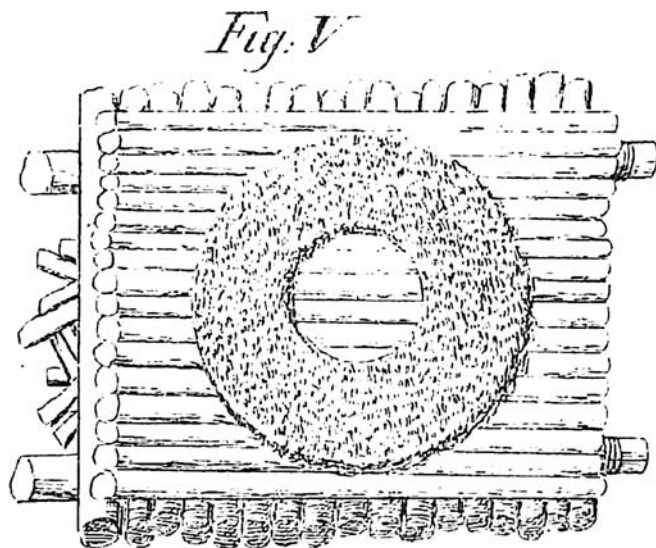


FIGURE 2.11 Sketch drawing of a roasting fire, after O. Evenstad (1782 [1960]) table 1

and are found in the border zones between mountain ridge bogs and dry land. They are often overgrown with grass and heather, and often have tall vegetation consisting of spruce and birch. Tapp John-Erik Pettersson²⁰⁷ emphasizes that the search for bog ore should be undertaken where there are narrow necks of bog. If the bogs are thickly overgrown with bog grass and bushes it is a good sign that bog ore may be formed there. Evenstad²⁰⁸ also pointed out the importance of saturation of the ground or small streams. If the areas are saturated, and are overgrown with tufts, grass, heather, humps and trees, the chances of finding outcrops of ore are good. Similar criteria for locating the material have been described by Falck-Muus, Hauge and Englund.²⁰⁹

Roasting and Roasting Places

The sites where the ore was collected from the bog and roasted are rarely described in the archaeological reports, a fact which is primarily due to the fact that the sites are not visible ancient monuments. Knowledge about bog ore and roasting methods in *jernvinna* is consequently largely derived from Evenstad's manuscript of 1782 (Fig. 2.11), and it is well described by, amongst others,

²⁰⁷ Pettersson (1982) 45.

²⁰⁸ Evenstad (1782).

²⁰⁹ Falck-Muus (1927) 379, Hauge (1946) 26, Englund (2002) 175–176.

Pettersson, the metallurgist Vagn Fabritius Buchwald and Espelund.²¹⁰ According to Evenstad, the roasting of ore was done on an open bonfire with crossing logs. The ore was placed on top of the bonfire. When the wood had burnt down, the ore was roasted through. By warming the ore to 675°C, a chemical process takes place in which the metal changes character from non-magnetic goethite to magnetic maghemite and takes on a deep red colour. There is a loss of weight at the same time. This is because chemically bound water has been removed and the organic material has been burnt up.²¹¹ In theory, the diminution through this process of smouldering will correspond to a weight-loss of about 10% if the metal is quite pure.²¹² However, there are impurities which mean that the reduction in weight will always be greater. Experimental roasting shows that the loss in weight can be between 15% and 65%, dependent upon the type of ore, the quantity of organic material and the level of drying beforehand.²¹³

Outside of Scandinavia, it is rock ore that has almost exclusively been used in direct iron production. The roasting technique was also different. First of all, there is an additional stage of production in that the rock ore has to be crushed into smaller pieces before roasting. The roasting of the rock ore itself was done in circular pits or elongated trenches ('roasting hearths').²¹⁴ This method is known over the whole of Europe.²¹⁵ Roasting on the ground surface is less common. In Norfolk, England, an ore heap has been described as the remains of repeated roasting on an open fire.²¹⁶ In the Middle Ages, rock ore was roasted in open stone furnaces,²¹⁷ a method that is also described and illustrated by Agricola.²¹⁸

Roasting is a simple process that does not require fixed structures. This means that traces of the activity most commonly only appear as thin layers of roasted ore lying on the ground. Experimental reconstructions of roasting following Evenstad's guidelines produce the same result. After the roasting fire has burnt out, the ore is collected. A thin layer of ore, ash and charcoal is left, as there was no wish to collect ore adulterated with sand from the ground. The result is that the roasting place will be completely invisible after the site has become overgrown again.

210 Pettersson (1982) 35–68; Buchwald (1998) 1–26, (2005) 134–159; Espelund (2004) 53–59.

211 Buchwald (1998) 22–23.

212 Andersson et al. (2006) 34.

213 Pettersson (1982) 58; Narmo (1996a) 65; Buchwald (1998) 23; Englund (2002) 211–213.

214 Pleiner (2000).

215 Tylecote (1987); Pleiner (2000); Schröfer-Kolb (2004).

216 Tylecote (1967).

217 Crossley (1981).

218 Agricola (1556 [1912]).

Separate roasting places have therefore not been recorded to any great degree, unlike charcoal pits. In light of the extent of production, it is logical to assume that ore-gathering sites and roasting places were widespread. The roasting places can be placed close to the ironmaking sites or to where the ore was gathered. Our information in Norway is largely derived from the major projects.²¹⁹ The roasting places that were identified by earlier studies are primarily found either on or close by the iron bloomeries. During survey work in the Gråfjell area, by contrast, roasting places were found at a considerable distance from the nearest bloomery site, and it was established that roasting, to a certain degree at least, was undertaken where the ore was collected as well as at the bloomery sites.²²⁰ The surveys were partly carried out using a magnetometer (see Ch. 3, Recent surveys and excavations).

Traces of the ore-gathering sites themselves are difficult to find, even though roasting areas beside bogs have been discovered. In fortunate circumstances they may be identified through shallow cuts, or traces of peat-cutting. Ore-collection was identified by Hauge in Numedal.²²¹ In bogs beside bloomery sites in Ängersjö in Sweden, it is also believed that there are traces of this activity.²²² Enormous amounts of ore were removed from the bogs. The fact that despite this, ore-gathering can only be identified in rare cases reflects the long period of time during which bog-growth and re-covering have erased the traces.

Because the roasting places and ore collection are almost invisible in the landscape, this category of ancient monument can virtually be described as the 'forgotten' monument. It is evident that roasting, just like charcoal burning, was profuse. Both the digging in the bogs and the use of wood must have been massive. As I shall show in due course, the number of roasting places is not lower than that of charcoal pits, especially in areas where roasting was carried out where the ore was gathered. If the raw ore is carried to the production sites the situation is rather different, as a place will by preference be used and reused a number of times. This means, in consequence, that roasting is also a central element in the organization of *jernvinna*, and that to understand the technology and use of raw materials in a comprehensive perspective, this feature of iron extraction must also be mapped out as best one can. In my analyses, I include roasting on exactly this basis, both by examining the process itself and by considering the role of roasting in terms of resources.

219 Narmo (1996a), (1997); Rundberget (2007).

220 Risbøl et al. (2002b) 55–57.

221 Hauge (1946) 27–28.

222 Emanuelsson (2001) 28–32.

Jernvinna in the Gråfjell Area—Conformity in Distinctiveness

Introduction

The material traces of *jernvinna* in the southern part of Hedmark County bear witness to a very widespread activity. In this chapter, I shall present and discuss the evidence from archaeological excavations in this region. The starting point is the archaeological work in the Gråfjell area, and this evidence is at the core of the discussion. I shall pick out certain examples and concentrate on the issues of technology and organization. I will also consider other relevant studies and put them into a common context with the Gråfjell area. Before starting, however, it is necessary to review the *status quo* before the Gråfjell Project. I shall begin by introducing the works of one of the great pioneers of bloomery ironmaking research in Hedmark.

Rolf Falck-Muus—A Major Contributor

Falck-Muus was a state geologist and natural scientist, but he had several particular interests in cultural topics. Amongst other things, he was fascinated by Finnish culture and settlement throughout his life, and passionate about numismatics. His enthusiasm for the Finnish culture meant that he was also especially interested in the border zones in Hedmark, which was the main area for the Finnish immigration in the seventeenth and eighteenth centuries. It was through visits to this area that he encountered the ancient *jernvinna*. Research into this rapidly became another passion, and he put a vast amount of work into charting bloomery ironmaking in the area.

In 1915, Falck-Muus began the cartography of Solør.¹ His first involvement with bloomery ironmaking was in 1926. In the following years he worked methodically on mapping and created for himself a good overview of this activity to the north up to Åmot Municipality² (Fig. 3.1). He linked Finnish settlement with *jernvinna* because the Finns were regarded as good ironmakers. His work

1 Falck-Muus (1927), (1979).

2 Falck-Muus (1931) 67, Fig. 11.

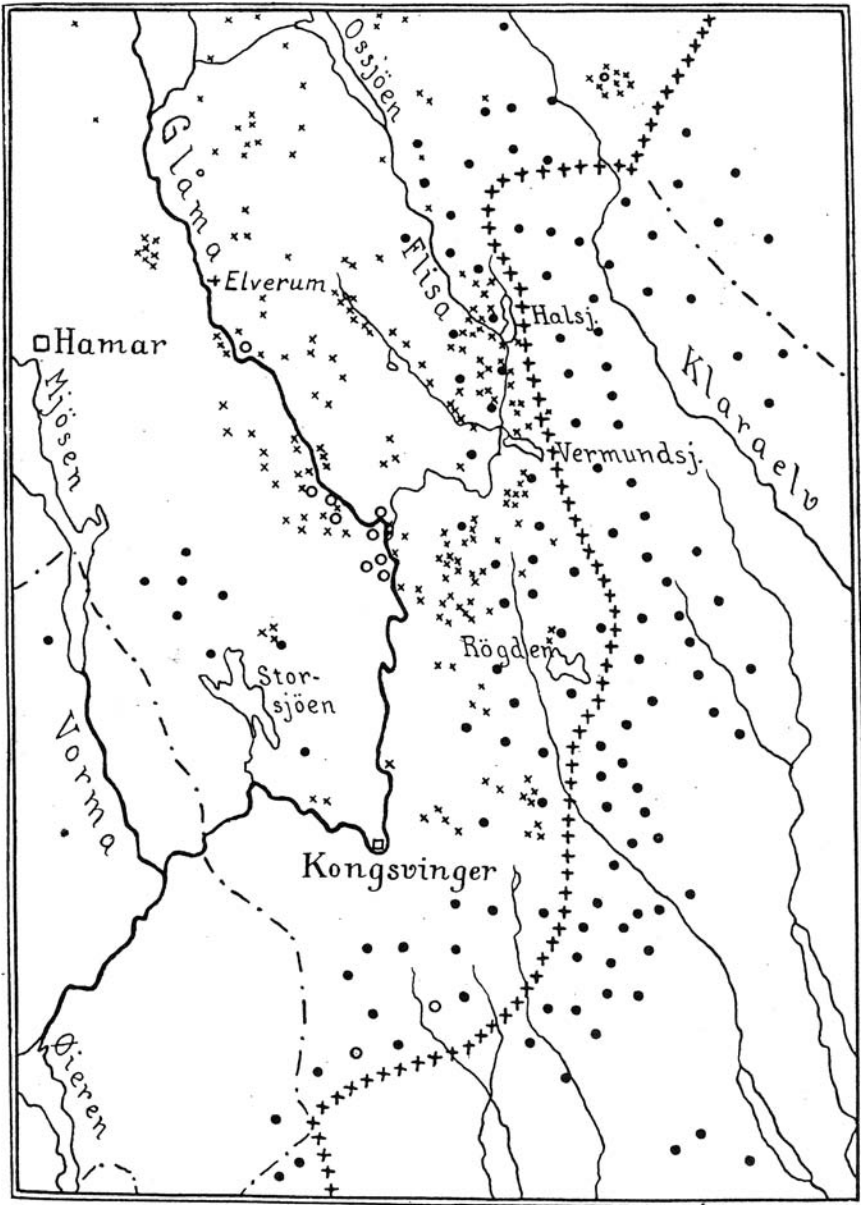


FIGURE 3.1 *Falck-Muus's map of bloemery sites from records and his own surveys, after R. Falck-Muus 1931:67, Fig. 11*

produced several publications proposing interpretations and hypotheses. The articles of 1927 and 1931 are regarded as his principal works. But he also wrote a series of more or less detailed publications³ in addition to several newspaper and magazine articles. His works and publications have since been discussed by the chemist Arthur Thuesen and Espelund.⁴

In 1926, he discovered nine bloomery sites, and was told of twelve more by the local people. What he identified to start with was primarily slag heaps. He describes a bloomery site as consisting of one or more of these. In several cases the heaps have a bowed shape around what he calls a mid-point, where he assumed the furnace had stood.⁵ The sketch from his investigations at the Tyskeberget site in Åsnes Municipality shows a slag heap of this kind.⁶ The bowed shape of the slag heaps is something that was later shown to be characteristic of the Hedmark tradition, and his inference of where the furnace was located was also subsequently verified.

It is quite difficult to interpret the excavation of the site at Tyskeberget (Fig. 3.2) and especially what he identifies as the hearth (the furnace). He describes this as a pit lined with flat stones and plastered with clay. For him, the pit was the furnace hearth itself. He interpreted the fragments of burnt clay,

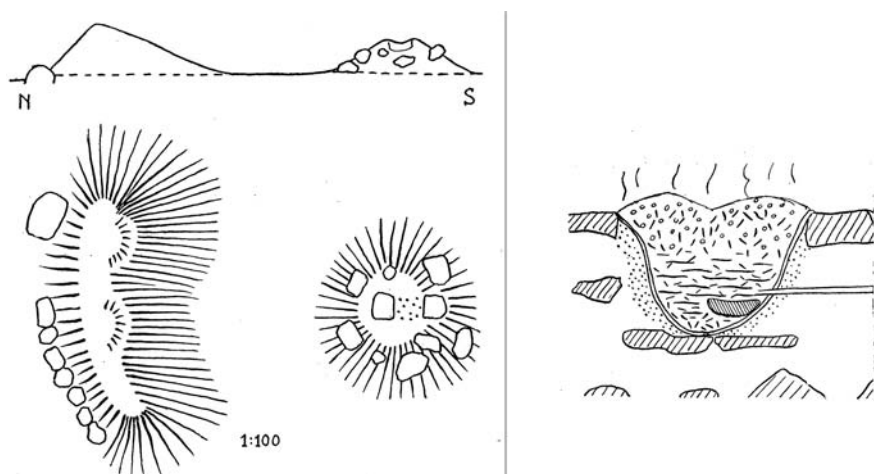


FIGURE 3.2 Excavated furnace hearth (isolation pit?) at Tyskeberget in Åsnes, after R. Falck-Muus 1926:333 and 1927:384, Fig. 10

3 Falck-Muus (1926), (1929), (1932), (1935), (1942), (1979).

4 Thuesen (1939); Espelund (1995).

5 Falck-Muus (1927) 359.

6 Falck-Muus (1927) 384, Fig. 10.

which can measure up to 28×16 cm,⁷ as coming from a clay lining of the walls within the hearth. From the description, the furnace type is reminiscent of a bowl furnace, a type that has not been identified in Norway (see Ch. 2, Slag tapping shaft furnaces in Norway). I believe this interpretation is mistaken, but it was presumably based upon the then current state of knowledge in which sunken furnaces were understood to be a widespread type. I assume that what he was looking at is an isolation pit for which parallels have been found in the Gråfjell area (see Ch. 3, The slag tapping furnace of the Gråfjell area—a distinct method). Finds of slag of Falck-Muus type 5 (see below), support this. An alternative interpretation is that this furnace may represent an early stage of the slag tapping furnace, a question to which I shall return in due course (see Ch. 8., The Hedmark tradition in time and space).

A central element in Falck-Muus's research is that he developed a typology involving an earlier and a later form of furnace based upon the classification of slag. The slag was divided into five categories according to form, structure and appearance,⁸ and, as will be shown below, this is very similar to the typology that was constructed on the basis of the bloomery ironmaking studies in the Gråfjell area.⁹

Type 1 is of varying size. The slags are heavy and dark, and include sand and charcoal. They are formed of several smaller pieces melted together and probably derive from a consolidation process.

Comment: What it is most appropriate to compare this with in the Gråfjell area was described as working slag, slag from the first consolidation.

Type 2 has a worm-like structure on the surface. On the underside, sand and gravel have congealed hard with the slag. This often has a convex form from a channel that the slag has flowed down.

Comment: This type of slag has much in common with what are described here as 'tapping plates'.

Type 3 is described as blue-black and heavy slag. It has a worm-like structure on the surface like Type 2 and has flowed slowly. From the form, which shows that it has been tapped from an 'eye' above the ground surface, he labelled this type a 'slag drip cone'. On the inside, the cone shows signs of having set against a convex surface. There are traces of burnt clay here which are from the exterior wall of the hearth.

⁷ Falck-Muus (1927) 360.

⁸ Falck-Muus (1927) 363–371.

⁹ Rundberget (2007).

Comment: This type is identical with what is referred to here as a 'tapping cone'. His observations of burnt-on shaft material inside the slag cones are important, and that they had a concave surface, even though he interpreted these as evidence of the hearth rather than as coming from a clay shaft above the ground.

Type 4 is a tight, stone-like, homogeneous slag, often full of blisters. This slag had set slowly at the base of the hearth and has a convex base mirroring the base of the hearth.

Comment: This type is equivalent to what are called 'base slags' in the Gråfjell area.

Type 5 is porous slag with large cavities from charcoal or wood. This slag had melted inside the furnace.

Comment: This type of slag is the hardest to interpret as it is of a typical form which is reminiscent, to a degree, of the Phase I tradition. In the Gråfjell area this type was formed in the isolation pits, and if it is found in association with Types 2 and 3, it can be securely associated with the Hedmark tradition.

Falck-Muus found no slag heaps in which slag of Types 2 and 3 was not represented.¹⁰ In the review of the sites he identified in 1926, the picture is pretty much the same, although it also transpires that slag of Type 5 was very common.¹¹ Later, he wrote that in all cases where finds of remains of a clay cap (shaft material) had been found, there was also slag with a worm-pattern.¹² From this, he concluded that this method must have been a later and improved technology which had superseded the simple embers of the fire with sunken vents (the bowl furnace). This conclusion seems to me to have its roots in his own discovery of slag tapping, which he saw in the context of the slag and the hearths that were found during excavations of Migration Period buildings in Rogaland and at Lista in Vest-Agder.¹³

He believed he had found remains of the earlier mode of production in only three places: a barrow that he dated to the 890s, a slag heap from Hof in Åsnes Municipality, and a find of slag from Våler Municipality. It is unclear what these finds really do represent, as the slag of Type 5 is, as noted, typologically similar to that of the earlier phase. Individual finds of slag cannot be used for classification on their own, although if a slag heap consists predominantly of

¹⁰ Falck-Muus (1979) 346.

¹¹ Falck-Muus (1927) 371–377.

¹² Falck-Muus (1979) 354–347.

¹³ Falck-Muus (1933) 93–94, (1936), (1934) 68–69.

Type 5 slag it is possible that it is a bloomery site of the Early Iron Age. In Elverum Municipality, several Early Iron Age sites have been identified, and one would expect that the technology was also known in Solør. From our present knowledge, Falck-Muus's slag types are significant for this area, and have clear parallels with the Gråfjell area.

One problem with Falck-Muus's early interpretations is the charcoal pits. To begin with, he paid little attention to the charcoal kilns, which he thought were of the type that stood above the ground level. However, he did accept that charcoal was used in iron production to some extent, and so had no doubt about the existence of kilns.¹⁴ Four years later he had changed his view. He was then convinced that charcoal had also been made in charcoal pits.¹⁵ Now, in the same way as he had done with types of furnace, he distinguished two methods of production chronologically: one using charcoal and one wood. The use of wood he assigned to the ironmaking that took place in improved furnaces of the seventeenth and eighteenth centuries, while the charcoal pits were much older. A central issue is Falck-Muus's description of charcoal-burning in eastern Norway being undertaken in square pits in contrast to round pits in other parts of Norway.¹⁶

Falck-Muus produced important conclusions in distinguishing between techniques on the basis of types of slag and the use of wood or charcoal. He placed the dividing line at the transition to the Scandinavian Middle Ages, *inter alia* on the basis of the fact that farms where slag was found were abandoned in the Viking Period. His knowledge of furnace types was adopted by Hauge,¹⁷ amongst others, although he does not refer to Falck-Muus very much.¹⁸ Unlike Falck-Muus, Hauge made better efforts to date *jernvinna*. In addition to the typology of slag, key factors for him were artefactual finds associated with bloomery sites, iron ingots of the *bleggøkse* type and iron bars in hoards, graves and buildings.¹⁹ He thus created a chronology of the development of furnaces from the pre-Roman Iron Age to the farmers' furnaces described in historical sources. Many decades later, the technological dividing line between phases 1 and 2 was confirmed by radiocarbon dating.²⁰

14 Falck-Muus (1927) 359.

15 Falck-Muus (1931).

16 Falck-Muus (1931) 57–58.

17 Hauge (1940) 56–59, (1946).

18 See Rundberget (2002a) 20.

19 Hauge (1946) 124–142, 204–217.

20 Narmo (1996a); Rundberget (2002a); Larsen (2004); Larsen and Rundberget (2009).

Falck-Muus was one of the most important pioneers in early bloomery iron-making research, and his work has been crucial to our knowledge of *jernvinna* in Hedmark, as well as providing much of the foundation for the way in which bloomery ironmaking research has developed.²¹ Equally, it is research on *jernvinna* in Hedmark for which he is best known. Many of his findings remain absolutely solid when looked at in relation to new results which have come to light since his work was undertaken.

Recent Surveys and Excavations

After Falck-Muus, attention to ironmaking in Hedmark lay thoroughly dormant except for some works of local history. Ancient monuments connected to *jernvinna* were mapped during surveys for the Economic Mapping of 1977 and 1986, but nothing followed that. However, the survey of the outlying land under the Åker Project in 1992–93, through which 1,209 monuments in the outlying areas were identified, showed that bloomery ironmaking had been widespread.²² The information thus obtained led to Hedmark County launching the project *Utmarksregistreringer i Hedmark*.²³ In all, this project recorded 5,840 ancient monuments, distributed across 14 administrative districts, in the period 1994–98.²⁴

Further mapping of outlying land was undertaken when the military moved out of Gardermoen and established the Østerdalen Barracks in Åmot Municipality. In connection with the planning conditions for the military zone, there were also many surveys of outlying land and a total of 1,800 ancient monuments were recorded in four areas.²⁵

Because of the activities associated with Østerdalen Barracks, Åmot is the best recorded administrative district of Norway with respect to the outlying areas. When Rødsmoen was developed as a cavalry training area, about a third of the area concerned was recorded. Altogether, 320 ancient monuments were identified.²⁶ The area was then investigated archaeologically in the period

21 Rundberget (2002a) 16–19.

22 Pilø (1994); Bårdseng (1998) 7.

23 'Surveys of Outlying Areas in Hedmark', referred to as 'Outlying Surveys', to distinguish from other surveys.

24 Bårdseng (1994), (1995), (1996a), (1996b); Holm (1998).

25 Mangset et al. (1996a), (1996b).

26 Thorleifsen (1993).

TABLE 3.1 *Numbers of pre-reformation ancient monuments in the outlying land recorded by major projects in Hedmark since 1992*

Survey projects	Monuments in total	Bloomery sites	Charcoal pits	smithies	Roasting pl.
Åker Project	1209	123 (10,2 %)	880 (72,9 %)	–	–
Outlying Surveys	5840	231 (4,0 %)	2511 (43 %)	–	–
Rødsmo Project	706	11 (1,6 %)	274 (38,8 %)	4 (0,6 %)	–
Rosland Surveys	1864	144 (7,7 %)	1387 (74,4 %)	–	–
Gråfjell Project	2457	115 (4,7 %)	1750 (71,2 %)	–	259 (10,5 %)
<i>Total</i>	<i>12 076</i>	<i>624 (5,2 %)</i>	<i>6802 (56,3 %)</i>	<i>4 (0,3 %)</i>	<i>259 (2,1 %)</i>

1994–96 under the title of the Rødsmo Project.²⁷ Further survey work was undertaken at the same time, and the number of protected monuments grew to 706 in total.²⁸

After Gråfjell was selected as an alternative regional firing range, NIKU undertook an archaeological survey in the period 1999–2002. This led to the identification of 2,191 automatically protected ancient monuments and 803 sites of the post-Reformation period.²⁹ Innumerable small or medium-sized planning cases through which ancient monuments have been recorded in outlying land should also be noted.

Altogether, since 1992, more than 19,000 ancient monuments have been recorded in the outlying land of Hedmark through the major projects (Tab. 3.1). In Åmot, 222 ancient monuments were known in 1993.³⁰ Today the number associated with economic activity in the outlying land exceeds 3,600. Despite the extensive survey work, however, we are still a long way from having the presence of ancient monuments in the outlying area representatively mapped.

²⁷ Bergstøl (1997); Boaz (1997); Narmo (1997).

²⁸ Narmo (1997) 7.

²⁹ Risbøl et al. (2002b).

³⁰ Narmo (1997).

The surveys in Hedmark show that it is evidence of bloomery ironmaking which provides the largest group of monuments. The picture fills out Falck-Muus's map of widespread activity over much of the region (Fig. 3.1). The distribution is uneven, a matter that I shall discuss later (Ch. 4). Looking at the proportions of sites from different periods, on the basis of types of slag, Bård-seng has assigned 15 sites to the Early Iron Age and 93 to the Viking Period or Middle Ages in Vangsåsen by the city of Hamar.³¹ In the Gråfjell area, only one of a total of 109 sites is from the Early Iron Age.³² In both areas, the Viking Period and Middle Ages are clearly best represented in the evidence, as the high proportion of charcoal pits also implies. This feature recurs over much of Hedmark: Early Iron Age production would appear to have been limited, while large-scale production was seen at the end of the Viking Period and early in the subsequent Middle Ages. There are exceptions, nonetheless: both at Hedemarken and in Elverum County several sites of the Early Iron Age have been recorded. In Åmot, two Early Iron Age sites have been identified, as well as the one in the Gråfjell area.³³ Also in Stor-Elvdal County four sites from the Early Iron Age have been detected, three of them are enormous. In the northern districts, Evenstad sites predominate.³⁴

Except at Rødsmoen, only one bloomery site from the Viking Period and Middle Ages has been excavated in Hedmark. A number of charcoal pits have been investigated, however. The first dating was undertaken when, in 1973, the Norwegian Forestry Museum undertook a comprehensive survey of pits in Svartholtet, Elverum.³⁵ But the first proper archaeological fieldwork took place at Grundset in Elverum in 1984.³⁶ Charcoal pits have since been examined and dated in all of the southern districts and northwards up to and including Alvdal County.

Bloomery Ironmaking in the Gråfjell Area—Form and Facts

With this review as a backdrop, I shall now turn to the actual excavation results from the Gråfjell area. The material examined comprises three principal categories, all of which will be described: bloomery ironmaking sites, charcoal

31 Bård-seng (1998) 18, 31–53.

32 Risbøl et al. (2002b) 53–54.

33 Pers. comm. Jan Henning Larse.

34 Nyeggen (2005); Espelund (2011).

35 Bloch-Nakkerud (1987) 65.

36 Mikkelsen (1986).

pits and roasting places. Because of the volume of evidence, it is impossible to go into detail with all of this comprehensive material. Consequently, I focus upon the central elements that I understand to be significant with respect to technology and tradition. This is done by taking examples of types and categories that are decisive for the interpretative discussion towards the end of this section.

Iron Bloomery Sites—Earlier Investigations and State of Research

As noted in the previous section, only three excavations have been carried out on bloomery sites in Hedmark other than under the Rødsmo Project. The Rødsmo evidence thus provided most of the basis for the recording and subsequent excavations in the Gråfjell area, reasonably enough as the area of survey practically abuts Rødsmoen in the south-west. The bloomery sites on Rødsmoen of the Viking Period and Middle Ages were classified as the 300-type and the 695-type, according to variations in their organization³⁷ (Fig. 3.3). The type of furnace was understood to be the same for both traditions. The differences in organization are, consequently, based on four features: the volume of production, the form of the slag heaps, the location of the furnace and stockpiles of raw material, and the presence or absence of a shed.³⁸ These were regarded as reflecting different ideologies, in which the organization and perception of *jernvinna* as a fixed structure or as the more mobile use of the outlying land were the most important alternatives.³⁹ A fundamental conclusion was that

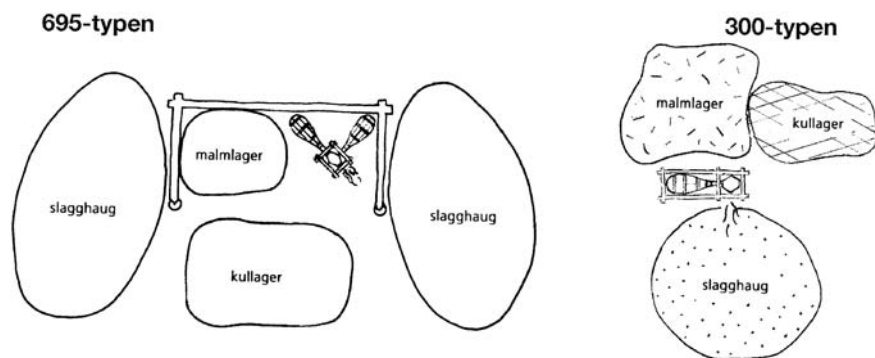


FIGURE 3.3 *Typological classification of bloomery sites at Rødsmoen, after L.E. Narmo 2000:148, Fig 65, MCH; and Risbøl et al. 2001:52, Fig. 56*

BOTH DRAWN BY MARIT HANSEN

37 Narmo (1997) 121–123.

38 Narmo (1997) 122, Fig. 75.

39 Narmo (1997) 133.

the 300-type had lower overall production than the 695-type sites, and that there was no sign of sheds on the smaller sites.

The recording of *jernvinna* in the Gråfjell area was founded upon these conclusions.⁴⁰ The ironmaking sites in the Gråfjell area were classified according to the types listed above. In the course of the registration project, however, the rigidity of that scheme of classification came to be questioned. This was because it transpired that there was complex variation, and that the application of this as a standardized typological scheme led to the discounting of variance. Despite this, the scheme was kept to throughout.⁴¹

In the course of the survey, NIKU identified 109 iron bloomery sites⁴² (Fig. 3.4, Tab. 3.2). 65 of these were released for excavation. 26 sites are located within established protected zones of the firing range. Excavations revealed five new sites and two new production sites at bloomery sites already registered. The total number of known bloomery sites in the military area itself is 96. The other 18 are situated outside the final boundaries of the firing range. All of the recorded sites are used in statistical studies (see Ch. 3, unexcavated bloomery sites) and in the topographical analyses.

Altogether, 39 bloomery sites were investigated. Two sites had two separate production sites (total = 41). Nine of the sites were surface-surveyed and 32 have been fully excavated. On the basis of our knowledge from the Rødsmo Project, principal attention should be paid to small and untypical sites.⁴³ Sites recorded as the 695-type are predominant. All of the sites of the 300-type and unclassified sites were fully excavated, with the exception of Jfp.38 (damaged),

TABLE 3.2 *Excavated ironmaking sites according to the recorded type*

Bloomery type	2001	2003	2004	2005	Total
695-type (53)	1	3	12	7	24
300-type (4)	—	2	1	1	4
Unspecified (5)	—	1	3	1	5
Smithy (2)	—	1	1	—	2
New surveyed (7)	—	—	4	3	7
Total (63)	1	7 (9)	21	12	41

40 Risbøl et al. (2000), (2001), (2002a), (2002b).

41 Risbøl et al. (2002a) 45, 48.

42 Risbøl et al. (2002b).

43 Amundsen (2003) 25–26.

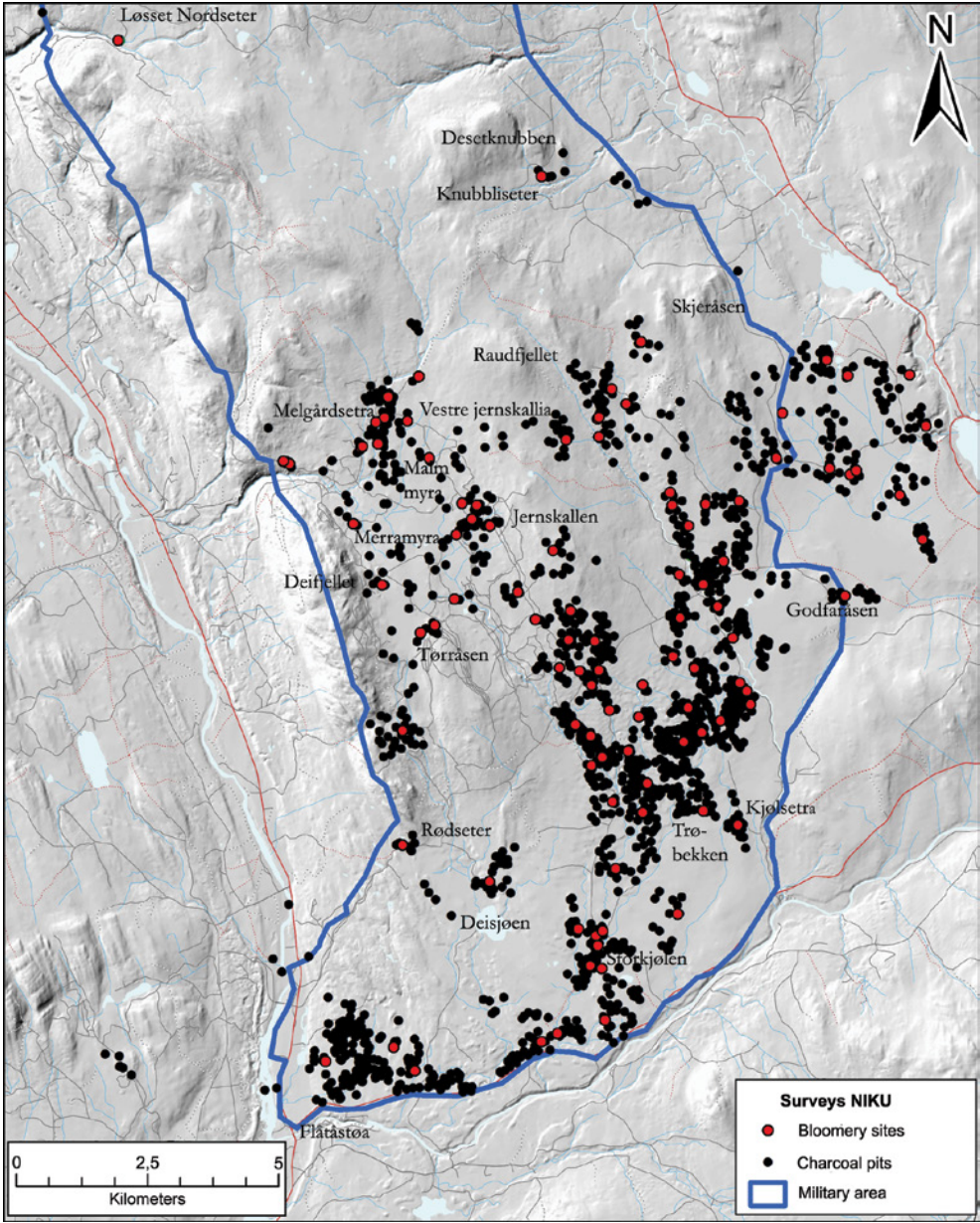


FIGURE 3.4 *Recorded bloomery sites and charcoal pits in the Gråfjell area*
MAP: D. HILL/B. RUNDBERGET, MCH

while a sample (45%) of the 695-type was excavated or surface-surveyed. NIKU recorded three smithies in the outlying land. Two of these were examined, and both were reclassified as bloomery sites. The third smithy, which is within a protected zone, I would also judge, from a survey, to be a bloomery.

A Brief Introduction to the Methodology

The bloomery sites were excavated using a strict stratigraphical method. In some cases, where the definition of sequences of layers was difficult, small trenches were dug with the intention of tracing the layers in section. Digging machinery was used to deturf the whole area of excavation, including the production areas. In order to identify possible traces of occupation or settlement, quite large areas around the production sites were stripped at several sites. Some cleaning was undertaken in these areas, as possible structures were usually easily visible against the soil.

The sites were documented before deturfing. Both manual (2003) and digital recording (2003–2005) were employed. Structures and layers were recorded on a context plan. Where finds and samples were collected was marked on the drawings. The plans of the site were done at 1:50, with detailed drawings at 1:10 or 1:20. Photographs of the individual layers and constructions, in plan and in section, were taken continually.

The slag heaps were sectioned by machine in quadrants so that both the long and cross sections could be recorded. In a selection of the slag heaps, 0.25m³ samples were taken in order to calculate the volume of slag (see Ch. 6). The sample was water-sieved and divided into three components: slag, shaft material and other. These were not subdivided by types of slag, as different places of deposition would give misleading figures.

Furnaces and the furnace zones were examined by open-area excavation, sectioning and emptying. Tapping slag lying *in situ* around the remains of the furnace could be extremely fragmentary, and was rapidly washed away. The remains of furnaces above ground level were therefore excavated in layers, while isolation pits were sectioned and/or emptied out.

Terminology

The need for consistency in conceptual and typological terminology rapidly became evident in the Gråfjell Project, both during excavation and subsequently for publication. The result was the production of guidelines for terms and their use. This list is, strictly speaking, a research output. It is, however, important to present the terminology at this early stage so that the terms can be used without repeated explanations. Below is a summary of the most important terms that are used in this publication.

The bloomery site

Bloomery/ironmaking site (Norw.: *jernfremstillingsplass/jernvinneanlegg*): labelled Jfp. The entire site and all of its components (Fig. 3.5).

Charcoal stockpile (Norw.: *kullager*): a store of charcoal at the bloomery site.

Ore stockpile (Norw.: *malm lager*): roasted ore at the bloomery site close by the furnace; may in some cases also be used in the context of roasting at the bloomery site.

Clay stockpile (Norw.: *leirelager*): a deliberately assembled deposit of burnt clay or fragments of shaft material, distinct from concentrations of burnt clay and shaft material in the slag heaps. The burnt clay was probably intended for tempering in the construction of new shafts.

Roasting place (Norw.: *røsteplass*): the area where the ore was roasted or reroasted. Roasting places have been identified both alongside bogs with bog ore and at, or immediately adjacent to, the production site (see also Ch.3., Roasting sites—a factor in a comprehensive understanding).

Slag heap (Norw.: *slagghaug*): slag accumulated in a mound above the ground (slag spread over sloping ground = *slag waste*).

Slag embankment (Norw.: *slaggvoll*): small heaps that extend the ends of the slag heaps into the production area. Their contents may be the same as the slag heap or may include iron-rich slag which has been deliberately placed here.

Production site (Norw.: *produksjonsplass*): all the components (ore and charcoal layers, furnace area and slag heap) which are directly part of basic production. A bloomery site may comprise several production sites (e.g. Jfp.3).

Production zone (Norw.: *produksjonsområde*): the area where the production itself was carried out within the production site; in other words, the area between the slag heaps which comprises the furnace area and the charcoal and ore layers. A production site may have several production zones.

Processing zone (Norw.: *bearbeidingsområde*): the area with slag that is interpreted as waste when cleaning the bloom directly after taking it out of the furnace. It is possible that the bloom was reheated as part of this process. This zone with post-reduction slag,⁴⁴ which is black or rust-brown, is documented as anything from fragments to plates several centimetres thick. Processing was carried out on the ground, on an anvil, or in a pit. Processing zones are found at several but not all excavated sites.

44 Pleiner (2000) 216–217.

Phase (Norw.: *bruksfase*): this may be defined as a specific period during which the site was in more or less continuous use, and in which activity is associated with the use of specific buildings, layers and structures. It should also be noted that phases of use of this nature are not synonymous with breaks in production. In many cases it can be suggested that new phases reflect reorganization of the production site. Reorganization of this kind may have a variety of causes, but would usually be attributed to a shift of position because of the volume of production and lack of room. Phases defined in this way can also overlap with one another, as components such as stores of raw material retain a fixed position throughout the period of production.

Furnaces

Furnace (Norw.: *ovn*): the furnace with all of its components.

Shaft (Norw.: *sjakt*): the word 'shaft' is used to denote that part of the furnace that is above ground-level and to refer to remains of shaft material at the site.

Isolation pit (Norw.: *isoleringsgrop*): a pit lying underneath the shaft furnace itself. The pit was not primarily constructed for the collection of slag and should not be confused with a slag pit. Usually constructed with stone edging and wooden stave lining.

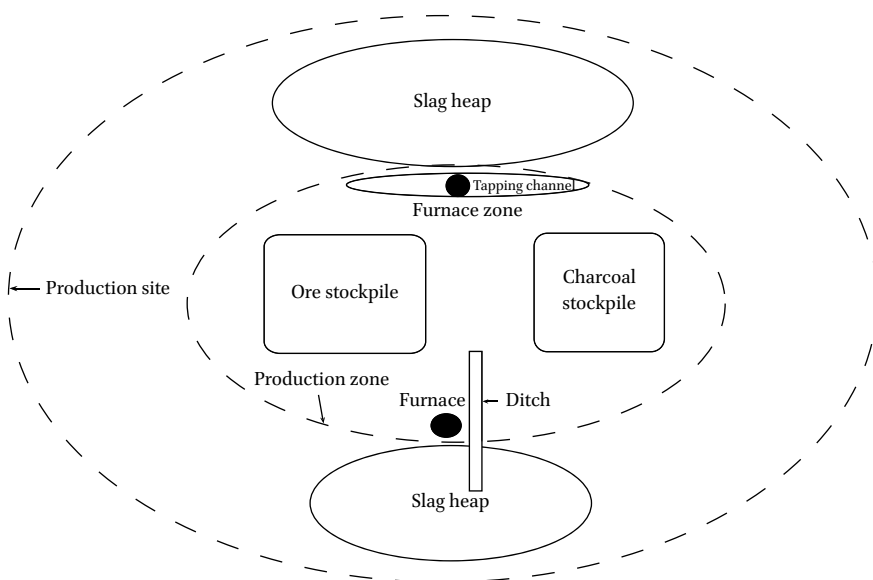


FIGURE 3.5 Overview of the most common components of ironmaking sites in the Gråfjell area

BY B. RUNDBERGET, MCH

Furnace zone (Norw.: *ovnsområde*): the area around the furnace. A furnace zone may include components such as an isolation pit, clay layer or shaft base, furnace shaft, tapping plates or cones, tapping channels or pits, and the base for a bellows.

Lining (Norw.: *lagg*): wooden panelling, described here as staves, constructed very like a wooden vat. Constructed within the isolation pits on the inner side of the stone edging.

Channel/Tapping channel (Norw.: *renne/tapperenne*): terms used for elongated cut features where the furnaces are often located. The channels that lie parallel to the slag heaps are interpreted as having been a construction for tapping out and are therefore a usual term for this type of structure.

Slag Typology

Slag is usually difficult to define, but it is an important issue for interpreting the bloomery ironmaking technology. Different types of slag at the same site can shed light on various phases of one process, or may provide information on purely morphological features of the furnace. Knowledge of slag types is also crucial in metallurgical research as it is a matter of great importance to know what is actually being analysed. In broad terms, typologies have been produced by excavations, being important for the purposes of recording. If those doing the recording have this knowledge, bloomery sites will be easier to classify both chronologically and spatially.

For this reason, it is important to lay out the basic criteria for a typological scheme. The criteria I have used conform partly to Narmo's definitions.⁴⁵ He differentiates between flowing slag which flows vertically down into a slag pit and slag that has been tapped horizontally in liquid state out of the shaft into a channel. For the former type he used the term 'slag lumps' (*slaggblokker*) and for the latter 'tapping slag' (*tappeslagg*). Defined thus, slag lumps are not present in the Gråfjell material except for in one case, and they are therefore not discussed further here.

Narmo intended tapping slag to be an umbrella term for slag tapped out of a hole in the furnace. It is important to be aware that the criteria were developed on the basis of the investigations at Dokkfloy, and are only partly applicable to the Gråfjell area. In both cases, the situation is that the upper surface of the slag has a flow-structure and the underside has inclusions of sand and gravel. A crucial difference, however, is that the slag in the Gråfjell area has been tapped from a certain height and not almost horizontally at ground level. As a result, the form of the pieces of slag is different in character from that at

45 Narmo (1996a) 14.

Dokkfloy. Tapping slag is used as a term in what follows with a wide application, and is thus a useful term for differentiating this type of slag from slag lumps⁴⁶ (see also Ch. 3, The slag tapping shaft furnace of the Gråfjell area—a distinct method).

From the results from the Gråfjell area, a more nuanced typological subdivision of slag has been undertaken. As noted, Falck-Muus also created a typology of the slags he found in his work. When compared, it is very clear that this typology is very similar to that I worked out for the Gråfjell area. The definitions are used consistently in the following text, and, like the terminology explained above, must be introduced before the review of the archaeological evidence.

Tapping slag

Slag beads (Norw.: *slaggeperler*): diagnostically round ‘beads’ formed by spurts during the tapping of slag under high pressure.

Tapping cone (Norw.: *tappekjegle*) (Falck-Muus type 3) (Fig. 3.6): slag tapped from a certain height against the outer wall of the furnace. Through repeated tapping the slag takes on a semi-conical shape, as it is rounded and widest towards the base. The form of the tapped slag can vary considerably while at the same time the slag shows signs of having flowed rather than taking shape as a result of dripping. The unmistakable conical shape is nonetheless a general characteristic, hence the term



FIGURE 3.6 *Tapping cone 23 cm high. Left: the surface has the form of set molten wax because the slag has been tapped out and set in the cold air. Right: the back was in contact with the shaft wall which has partly melted into the slag*

PHOTO: M. TEIGEN, MCH

46 Rundberget (2006) 23–24.

‘tapping cone’. Several tappings over time where the slag sets between the tappings mean that the volume and weight of the cone can be very great. The largest tapping slags weigh more than 60 kg and have been tapped from a height of more than 35 cm. Tapping slag often appears only in fragmented form. It has either been crushed when thrown on to the waste heap, or could have been shattered by frost, and is therefore difficult to classify with confidence.

Tapping plates (Norw.: *tappeplater*) (Falck-Muus type 2) (Fig. 3.11): tapping slag which appears in the form of flat plates. The plates are a modification of the tapping cones when the slag has flowed out over the flat ground. Tapping plates are often found as several, thin, accumulated layers.

Tapping slag set in the pit (Norw.: *tappeslagg størknet i grop*) (Falck-Muus type 5) (Fig. 3.7): an umbrella term for slag that has been tapped out and has flowed down into the pit between the stone edging and the wooden lining, and in some cases right down to the base where it has flowed into the pit. The slag, which has a horizontal solidification structure, has often formed around stones or the wooden lining, whence the description as ‘slag with wood impressions’ (see below).



FIGURE 3.7 *Tapping slag that has run down between the stones in the pit wall and set against the staves, which have left clear imprints. The horizontal strings of slag at the bottom show that the slag came down in portions and was partially set before the next flow*
PHOTO: M. TEIGEN, MCH

Other slag

Post-reduction slag (Norw.: *bearbeidingsslagg*) (Falck-Muus type 1): slag of varying character which has been mechanically solidified under heat and pressure ('sintered') during the consolidation of the bloom directly upon removal from the furnace, or after reheating. This slag has a black to dark brown colour and can on occasion remind one of asphalt or tarmac because of the sintering.

Base slag (Norw.: *bunnskolle*) (Falck-Muus type 4) (Fig. 3.8): slag that is formed in the base of the furnace. When complete, it has a flat to concave shape on the upper side. The underside, which lay on the threshold of the isolation pit, can take two forms: it can be almost convex or set solid with a partially reduced, porous and sintered mass of charcoal, ore and sand, and fragments of tapping slag. The sides often have impressions of wood from setting against the top of the lining. The usual term *plano-convex slag* is not used due to the varying shape on the underside.

Pit slag (Norw.: *gropsslagg*) (Falck-Muus type 1): an umbrella term for slag that is found in the isolation pits, inside the lining, and which is not to be confused with slag lumps (see the Phase I furnace). This slag has two principal forms; a heterogeneous, solidified mass with several ingredients, or slag similar to base slag.

Slag with wood impressions (Norw.: *slag med treavtrykk*): slag that has set against the wooden lining. This can be tapping slag flowed down into the pit between the stone edging and the wooden lining or base slag formed within the furnace (Fig. 3.7).

The Archaeological Investigations

Bloomery Sites

Of the 39 sites examined (Fig. 3.9), I shall focus upon three bloomery sites of varying degrees of complexity. The main objective is to show that, despite the difference in size, there is a high level of homogeneity, a point that is crucial to the subsequent analyses. I shall concentrate on elements of relevance to the structure, organization and phases of use of the sites. In addition, some unexcavated sites are presented in order to show how surface studies can provide supplementary information for our interpretation of a large body of evidence. Core features of all excavated and unexcavated sites are also found in Appendix Ia–b.

The presentation of the evidence is followed by a concluding discussion in which a number of key points are considered. Four issues are emphasized here as especially fundamental: technology, organization, material similarity and individuality.



FIGURE 3.8 *Upper: a nearly complete base slag with the shape of the circular furnace wall. At the top, the impression of the staves can be discerned, and at the very top of the picture is the imprint of the furnace mouth. Below: the underside with the impression of the staves in the lining. The fill varies from homogeneous and compact at the upper side to porous and mixed on the lower side. This is to be viewed in connection with the sequence of production, with the fill having passed through the shaft early in the process without having been transformed into slag*

PHOTO: M. TEIGEN, MCH

Bloomery Site Jfp.3

Bloomery site Jfp.3 was classified as a site of the 695-type during survey, with two parallel, oval slag heaps.⁴⁷ The site was excavated in 2003 and in the following season magnetometric surveys were undertaken in the area around the site;⁴⁸ these revealed an unknown production site (referred to as production site 2), 20 m south-west of the site recorded by NIKU, production site 1.

Production Site 1

Slag Heaps

Slag heap SH₁ lay to the south-west, and was of a roughly oval shape (Fig. 3.10). In its long-section two layers of slag could be identified. To the south-east lay a

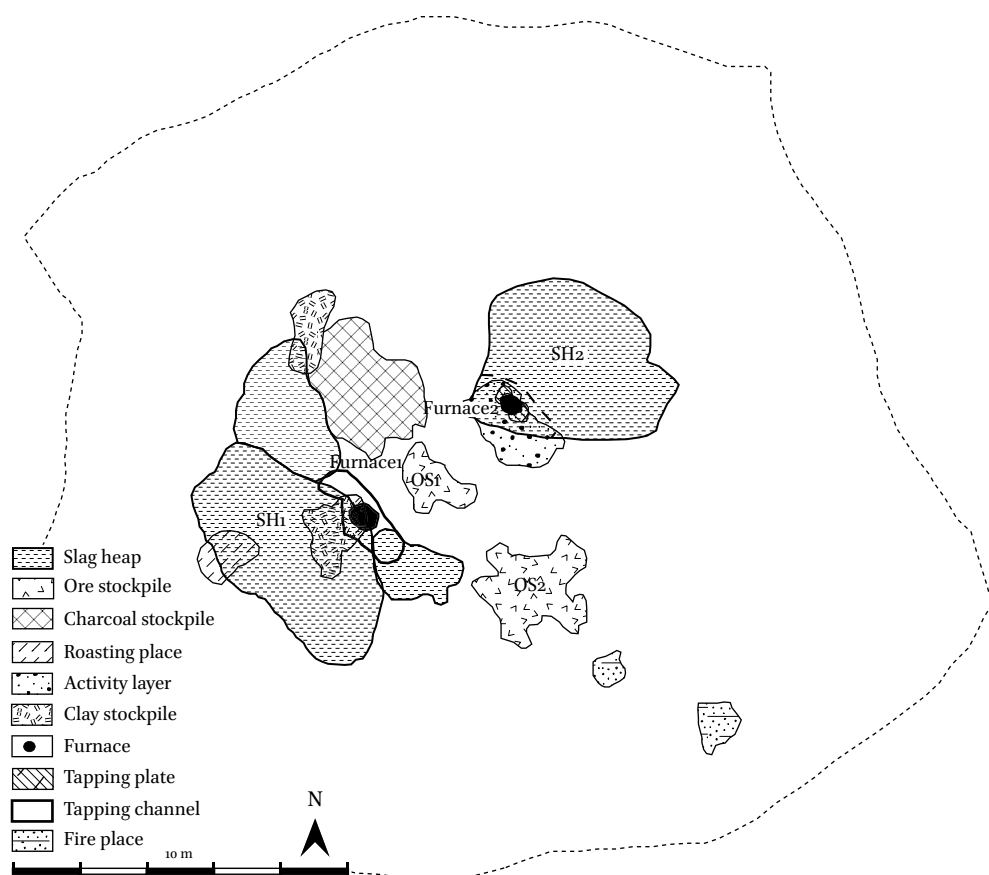


FIGURE 3.10 *Jfp.3: plan of production site 1*
BY S.A. LUNDØ/B. RUNDBERGET, MCH

47 Risbøl et al. (2000).

48 Smekalovs (2006).

smaller concentration, partly consisting of very iron-rich slag that was presumably a deposit of slag intended for secondary reduction. A rectangular roasting place was identified beneath and west of SH₁. The presence of charcoal and fire-cracked stone in the ore layer indicates roasting here. SH₂ to the north-east was roughly circular in shape. This heap consisted of four separate layers, all made up largely of tapping cones and fragmentary tapping slag, mixed with sand, burnt clay and charcoal. A quarter of a cubic metre was taken from both heaps, and through weighing and calculation of volume, the total quantity of waste at production site 1 is measured at 24.6 tonnes (t) (Tab. 3.3).

Stocks of Raw Material

A charcoal stockpile lay between the two slag heaps to the north-west of the production area. This was homogeneous, made up of pure charcoal and charcoal dust. This pile, which was the only one found, points to unvarying organization throughout the period of production.

However, two possible ore stockpiles were identified. One was in the middle of the production area and the other in the south-east. Despite the fact that these lay apart from one another, it is uncertain whether or not we should consider them one or two stockpiles. What suggests two separate piles is the extent of the layer in the middle, which is bounded by a cut feature.

A dense layer of red burnt clay lay directly to the north-west of the charcoal stockpile. This is interpreted as a stockpile of broken shaft material that was intended as temper for new shafts.

TABLE 3.3 *Measurements and volume of slag heaps from production sites 1 and 2 at Jfp.3. The weight of the slag heaps SH₃ and SH₄ is calculated from the average of all measured slag heaps in the Gråfjell area (cf. Ch. 6). It should be noted that the slag heaps at production site 2 contained a lot of admixed sand and that the proportion of slag is probably less*

	SH ₁	SH ₂	SH ₃	SH ₄
	<i>Production site 1</i>		<i>Production site 2</i>	
Measure	6,6 × 4,5 m	5,6 × 4,5 m	5,8 × 5,6 m	5,0 × 5,2 m
Height	0,7 m	0,7 m	0,1 m	0,1 m
Volume ¼ m ³	280 l	290 l	–	–
Weight ¼ m ³	478,5 kg	551 kg	–	–
Volume	12,1 m ³	9,9 m ³	1,6 m ³	1,3 m ³
Weight total	23,2 ton	21,8 ton	3,0 ton	2,3 ton
Weight slag	14,2 ton	10,4 ton	1,9 ton	1,5 ton

Furnaces and Furnace Zones

Furnace 1

The slag heaps were bounded by the locations of the furnaces, and these lay in the space between and close up to the slag heaps. The furnace zone beside SH₁ appeared in plan as a considerable concentration of burnt clay and shaft material. The clay layer is interpreted as the remains of a collapsed shaft. The layer extended partly over the slag heap and shows that the shaft must have fallen to the south-west.

Parallel with SH₁, below the concentration of clay was an elongated channel. The channel was filled with crushed tapping slag, burnt clay, some charcoal, and sand. In the centre of the channel a circular pit had been dug, with partly stone-lined walls. This pit had been part of the furnace structure. Within this stone edging, stave-built lining had been placed. The staves had been cut almost square in cross-section and tapered towards the bottom. Through the ironmaking they had been charred but not burnt away. The interior diameter of the pit was 35 cm and its depth 40 cm. It was filled with a disturbed layer consisting of charcoal, burnt clay, pieces of shaft material, and a large base slag weighing 18.8 kg and with impressions of wood. This filled much of the pit. The position of the pit in the channel indicates that tapping was done in two directions. The furnace shaft was, as noted, ruined, and the position of the shaft material directly over the pit indicates that the shaft had been raised immediately above the pit. The pit therefore gives us the diameter of the shaft.

Furnace 2

The furnace zone associated with SH₂ appeared as a raised area that merged into the slag heap. On cleaning, two concentrations of burnt clay and shaft-fragments emerged. This shows that the shaft had split in two directions rather than having broken down. Below the divided shaft lay thick layers of tapping slag. At the top the slag was fragmentary, but after cleaning, two large tapping plates were found *in situ*. The tapping plate to the south-east measured 0.8 × 0.5 m and was up to 10 cm thick. The plate to the north-west measured 0.6 × 0.4 m and was at most 7 cm thick. A number of thin slag layers show that tapping had been carried out bit by bit.

Between the tapping plates, the bottom 25 cm of the furnace shaft had survived. The outer diameter was measured at 55 cm and the internal diameter at 38 cm. A tapping hole was found in the south-eastern part of the shaft, 22 cm above the ground surface. The location of the tapping hole agrees well with the tapping area and the tapping plate to the south-east. A thin layer of charred wood edged the outer face of the shaft. This was what was left of a light structure consisting of pine and spruce bark. It was only preserved on the



FIGURE 3.11

Jfp.3: furnace 2 at production site 1. The lower part of the furnace shaft was preserved as the furnace was partially covered by tapping slag from the final smelting. The furnace has been cleaned off and only the lowest tapping slag remains in situ as tapping plates. It is clear that tapping was undertaken in two directions

PHOTO: B. RUNDBERGET,
MCH

south-western side facing the production zone, to a height of 2–3 cm. The bark had been placed in several layers.

The furnace shaft was set 5 cm into the ground and at the bottom it had been dug into a pit in which pieces of a base slag lay *in situ*, at the level between the pit and the shaft. This piece of slag bore impressions of wood from the charred, but surviving, remains of lining in the isolation pit. The lower parts of the staves were unburnt, and had rotted away, leaving voids. Stone had been used in some places as a foundation for the lining of the pit. The internal diameter of the isolation pit was 39 cm and it was 47 cm deep. When tapped out, slag had found its way between the stones edging of the pit. A porous lump of pit slag weighing 29.5 kg was partially melted fast on to the bottom of the base slag, and filled much of the pit.

Evidence of Occupation

Two fireplaces consisting of charcoal, fire-cracked stone, sand and some ore, lay immediately to the south-east of the production zone. In the more south-easterly hearth were found fragments of burnt bone, one piece of which has been identified as sheep or goat.⁴⁹

49 Hufthammer (2004).

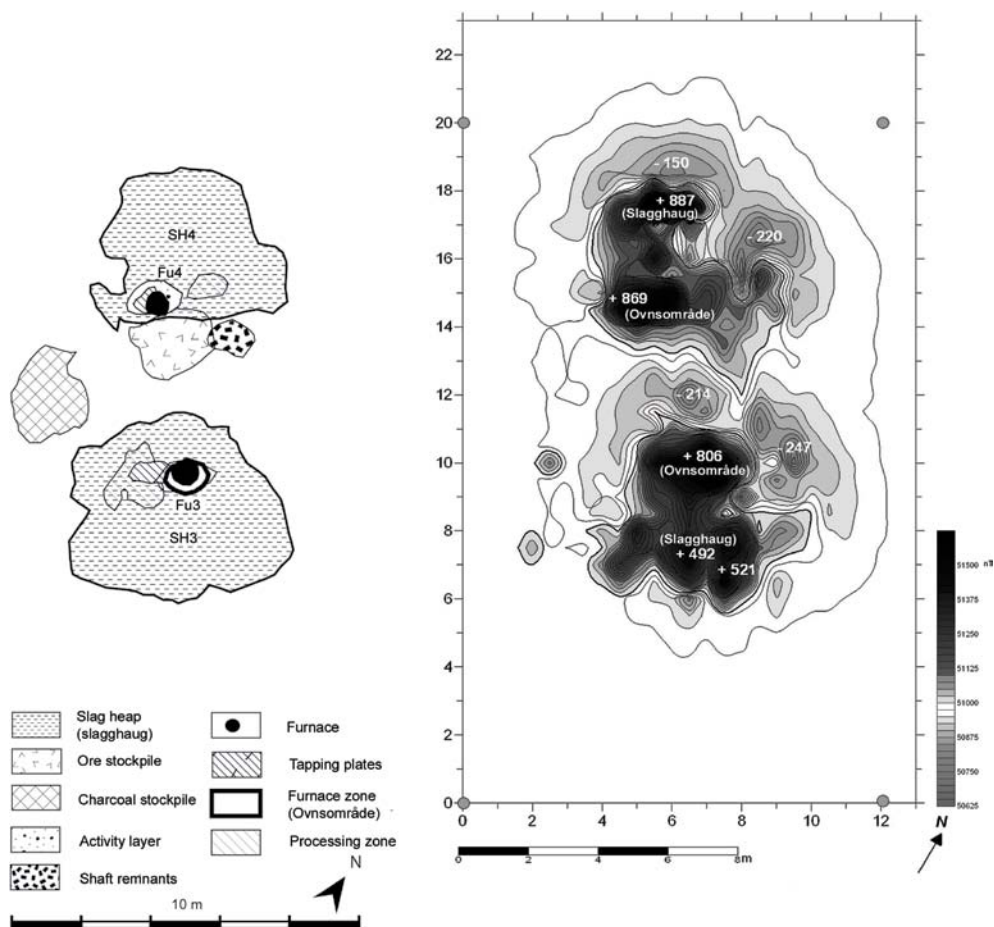


FIGURE 3.12 *Jfp.3: left, plan of production site 2. To the right, the same production site mapped by magnetometry. There is a good agreement between the drawn plan and the magnetometry survey*

BY S.A. LUNDØ/B. RUNDBERGET, MCH; MAGNETOMETRIC MAP PRODUCED BY SMEKALOV FOR MCH

Production Site 2

This production site was found by magnetometry, and before excavation a detailed survey was undertaken (see Ch. 3, Roasting places) by which magnetic anomalies were measured and mapped.⁵⁰ In Figure 3.12, the agreement with mapping from the geophysical survey and planning shows clearly that this method is a good way of mapping the components of a bloomery site.

⁵⁰ Smekalovs (2006).

Slag Heaps

The production site consisted of two slag heaps, SH3 to the south-east and SH4 to the north-west. Both were low and were eroding, and there was only a small amount of slag. The fill of SH3 consisted of a mixed layer of sand, tapping slag and some shaft material. Part of the heap was a porous, brown-black plate consisting of combined iron-rich slag, sand and fragments of tapping slag. This is interpreted as production slag. SH4 was rather more stratified, and the slag layer was mixed with sand. In the centre lay a concentration of very iron-rich slag. The furnace was also situated here within the slag heap itself. The deposition of slag points to short-term production, possibly a single season.

Production Zone and Raw Material Stockpiles

The production zone lay between the slag heaps and a roughly square charcoal stockpile lay to the west. A stock of ore was placed between the slag heaps to the east.

Furnaces and Furnace Zones

Furnace 3

The furnace zone to the south-east was identified as a thin layer of tapping slag in SH3. The location could be confirmed by a tapping plate that had not been removed after the final smelting. The tapping plate lay immediately to the east of a cut feature that formed a pit like those on production site 1. The pit was full of ore, slag and charcoal which probably derived from the initial phase of the process. It was stone-walled, and a rectangular lining of charred staves stood on the inside of this. The slag had partly flowed down between the stone edging and the staves. The pit had an outer diameter of 68 cm and measured 32×42 cm internally. It was 32 cm deep. The form of the shaft was indeterminable.

Furnace 4

The furnace zone to the north-west was covered with a layer of slag that merged into SH4, as with furnace 3. Some parts of the furnace shaft survived on the south-western side. The furnace wall had a height of 27 cm and it was clearly rounded. Directly outside the furnace wall were remains of a tapping plate measuring 45×75 cm and 10 cm thick. In a pit immediately below the clay shaft were pieces of a base slag. The fill beneath the base slag consisted of secondarily heat-affected slag mixed with ore, charcoal and sand. This pit too had stone-walled sides with a circular internal lining of staves. The diameter of the cut for the pit was 90 cm and the internal diameter 46 cm; it was 45 cm deep. This size corresponds with the curvature of the surviving piece of the furnace shaft.

Charcoal Pits

Jfp.3 is sited somewhat away from other known sites, and 15 charcoal pits securely linked to the site were examined. Fourteen of these pits were classified as square and only one as rectangular. Ten charcoal pits were sectioned, and only one phase of use could be identified in all of them. In three of the pits it could be determined that the wood had been laid in one direction. The sections of the pits were positioned so that it was possible to study possible removal of charcoal in the direction of the bloomery site. This was clearly the case with four pits, while one was emptied in the opposite direction.

Species of Wood and Dating

Twenty-three identifications of species show that pine was preferred for production, while in four pits spruce had been used. A total of 20 samples were dated. There is a detailed discussion of the dating of bloomery sites in Chapter 5. I report here that the period of use of the site was from just before AD 1000 to some date in the thirteenth century, and that production site 2 has an earlier phase of use than production site 1.

At least eight of the charcoal pits can be linked to production site 1 by date. A dendrochronological sample from charcoal pit Jfp.3-13 has been dated as having been cut after the summer of AD 1221 (NoH0127), in good agreement with the radiocarbon dating (T-18334, 840 ± 75 BP, cal AD 1065–1280). One charcoal pit, Jfp.3-12, has a dating to before the iron production (T-16907, 1180 ± 60 BP, cal AD 780–965). This is one of the earliest dated charcoal pits in Gråfjell, and, as things stand, it has no direct chronological counterpart amongst the known bloomery sites. The dated sample, however, was of pine and may, if we allow for a great time-width, be related to production in furnace 3 of production site 2 (T-17660, 1070 ± 65 BP, cal AD 895–1020).

Interpretations of the Bloomery Site

Jfp.3 consisted of two production sites, and bloomery ironmaking was practised almost identically, both in terms of organization and furnace type. At both sites there were two furnaces with associated slag heaps. Only one certain stockpile of charcoal and one of ore has been identified, with two phases of use in the ore stockpile at production site 1. Shared raw material stocks indicate that the furnaces were used at the same time, perhaps overlapping. Production site 2, with its low and spreading waste, had a short period of production, probably one season. Altogether, there was 2.9 m^3 of fill in the heaps, and the quantity of tapping slag here was small.

Bloomery Site Jfp.16

Bloomery site Jfp.16 had one slag heap and was classified as 'non-specific'. The production site lay 250 m south of the old shieling at Rødsetra, which had been in use back in the eighth century.⁵¹ Immediately south-east of the site lies the old access route to the shieling. Ironmaking in this area was limited, with no other sites within a 2 km radius.

Slag Heap

The recorded slag heap lay east of the production site and its shape had originally been roughly circular (Fig. 3.13). The fill was homogeneous and consisted overwhelmingly of crushed tapping slag, mixed in with fragments of base slag and a lot of sand/gravel. Directly below the heap lay a thin layer of charcoal.

A quarter of a cubic metre of the heap was sieved to analyse the fill and exploitation. Both the weight and the quantity of slag are low in comparison with other sites where such figures have been obtained (Appendix III). The profile of the slag heap showed the presence of slag to have been high, and this situation is assumed to reflect where the fill was taken from. Calculation sets the volume of the heap at 4.3 m³. This converts to 2.5 t of slag.

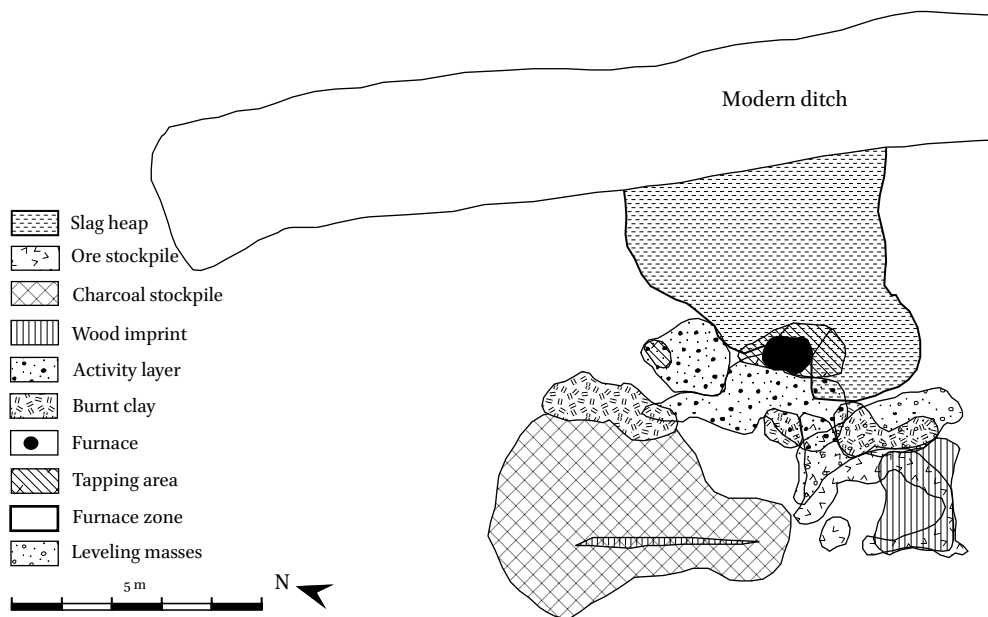


FIGURE 3.13 *Jfp.16: plan of the ironmaking site*
BY P.D. FREDRIKSEN/B. RUNDBERGET, MCH

⁵¹ Amundsen (2007).

The Production Zone and Raw Material Stocks

West of the slag heap lay a thin layer of fragmented charcoal of roughly square outline. This abutted, and was plainly bounded by, a morainic ridge to the west. Beneath the charcoal layer and up against the ridge, the impression of a lying log was discovered. This shadow was 1 m long and 10 cm thick.

A rectangular, patchy, pile of ore lay up against the charcoal stockpile to the south. Against the morainic ridge, the impression of another log could be identified beneath the ore layer, with the same alignment as that below the charcoal. One more shadow lay at a right angle at the south-western corner of the stockpile of ore. There were also traces of a corner to the south-east. The average width of the impressions was 10 cm.

Clay Layer

A layer of burnt clay lay east of and partly underneath the charcoal pile, and a corresponding clay layer lay east of and abutted the ore pile. Below the layer of clay, alongside the ore pile, there was also a disturbed layer of sand, gravel and burnt clay, and beneath that a thin layer of charcoal appeared, with the same extent as the stockpiles of raw material. This thin layer is interpreted as having been produced along with that beneath the slag heap; they are probably remains of the old ground surface which had been burnt, perhaps in clearing the area for the site to be constructed.

Furnace and Furnace Zone

Up against the slag heap lay a disturbed layer of sand, gravel, ore, charcoal, shaft material and some fragmentary tapping slag. This activity layer was elongated and extended between the clay layers. Partly below the activity layer appeared an oval hollow, aligned north-south, and measuring 2.0×1.3 m. In the middle of this, a pit could be discerned as a dark oval feature measuring 1.0×0.7 m. The hollow around the pit had been used for tapping out and its fill consisted predominantly of fragmented tapping slag. Right up against the outer wall of the pit to the south was a compact tapping plate. No sign of the furnace shaft was found in the furnace zone apart from a number of shaft fragments.

The edges of the pit were constructed of stone and base slags. The remains of a lining of 12 staves within the stone edging remained in place at the bottom. Both the stone edging and, to some degree, the staves were covered by tapping slag which had flowed down between the stones from the outside. The fill of the pit was consistently made up of an incompletely sintered mixture of sand, charcoal, ore and slag. The depth of the pit from the top of the stone edging was 35 cm but the depth from the ground surface was fully 65 cm. The tapping

pit around the isolation pit was 30 cm deep and corresponds nicely with a 35 cm tall tapping cone which thus was tapped from just above the ground surface.

Charcoal Pits

Four charcoal pits surround the bloomery site. All of the pits have a square base and one had been used at least twice, possibly more. The relationship between the volume of production and the demand for charcoal implies a minimum of five charcoal burnings from a median charcoal pit (see Ch. 6).

Wood Species and Dating

From the site and the charcoal pits, 10 samples were identified to species, and 9 of these were dated. Only pine was used in production. The dates are discussed further in Chapter 6, but I conclude that the site was most probably in use in the period c. AD 1175–1250. The thin layer of charcoal beneath the slag heap and the clay layers have an earlier dating, c. AD 820–955, and are not directly connected with the bloomery ironmaking.

Finds

A fragment of a flat iron artefact measuring 70 × 70 mm was found (C54071/1). This was slightly curved up on one side, and on this edge there is a nail hole and the remains of two nails still in position. The piece is probably from a spade or something similar. In charcoal pit Jfp.16–4, which was subsequently reused as a hunting trap, a shoe-buckle of copper alloy (C52709/1) was found.⁵² This is typologically of the form of Ross Whitehead buckle 631, dated to AD 1650–1750.⁵³ In light of the inference of a later hunting-pit phase which continued into the seventeenth century,⁵⁴ the buckle should be assigned to this later activity.

Interpretation of the Bloomery Site

The dates imply that the area in which the bloomery site was placed had been cleared several centuries before iron extraction started. The dates from the Rødsetra area show that there had been activity here since the eighth century, and the clearance can be associated with that. Stene⁵⁵ has discussed the phases of activity at Rødsetra, which she has divided into two periods, one in the Viking Age (c. AD 700–1000) and one in the Late Middle Ages, primarily from

⁵² Bøckman and Bergstøl (2001).

⁵³ Whitehead (1996) 100.

⁵⁴ Amundsen (2007).

⁵⁵ Stene (2014).

the fourteenth century to the middle of the seventeenth century, but with its first signs from the first half of the thirteenth century. In the first period, pastoralism was dominant, and there are extensive signs of burning. No traces of buildings from this period have been found. The thin layer of charcoal beneath the bloomery site should, I believe, be assigned to this context. In the later phase, the cultivation of crop plants was introduced alongside pastoral farming. The earliest buildings of this period are dated to the fourteenth century. From the position of the bloomery site, I infer that Jfp.16 is to be linked directly with this period of use for Rødsetra. It may, therefore, be possible to date iron extraction to the first half of the thirteenth century, but if so, towards the end of that 50-year period.

The organization of the ironmaking activity is simple to see on the evidence of the principal components. The process of charging with charcoal and ore and the use of bellows seems to have been practised in the area west of the furnace, between the stockpiles of raw materials. This is corroborated by the evidence of activity.

Of especial interest are the impressions of logs on the edge of both stockpiles. In the field, these impressions were interpreted as a built structure, possibly in the form of crates or bins in a rather portable sort of structure for keeping charcoal and ore in. On the western side of the piles, however, the logs lie in a more or less straight line, and it is possible that there was some superstructure over parts of the production zone.

Bloomery Site Jfp.20

Bloomery site Jfp.20 was classified on the basis of two slag heaps lying parallel as a 695-site. According to the survey report, there had been a shed between the slag heaps which was clearly represented by mounds constructed of sand and clearance stones to the east.⁵⁶

The investigation demonstrated that the site consisted of two, elongated, parallel slag heaps, aligned east-west, with SH1 to the north and SH2 to the south. The distance between the slag heaps was 6.5 m. Two furnaces were identified in association with these slag heaps, and four storage places between the slag heaps. A little to the east of the production site, a culture layer including two hearths was uncovered, and there was a roasting place to the south-west.

56 Risbøl et al. (2001).

Slag Heaps and Concentrations of Slag

Slag heap SH₁ lay to the north (Fig. 3.14). It was oblong (7.2×5.0 m) and aligned east-west. The fill of the slag heap was homogeneous, consisting primarily of tapping slag, some fragmentary base slags, and sand. Calculation of the volume of the slag heap put the quantity of fill at 18.8 m³.

Associated with SH₁ were two slag embankments which stood almost at right angles to either end of the slag heap. The mound to the west was roughly round, and it contained a brown, sandy, layer of slag made up of fragmented base slags and porous, gravelly, sintered slag. There was no tapping slag in this embankment. It lay partly beneath SH₁ to the north. The type of slag implies that this area was used for consolidating the blooms.

SH₂ was also oblong (7.9×5.4 m) and lay parallel to SH₁ to the south. This slag heap consisted, at the top, of a brown layer of tapping slag with an admixture of sand and charcoal. In the middle there was a large proportion of broken shaft material and fragmented base slags, while the lowest layer consisted primarily of tapping slag. This heap had a volume of 17.6 m³.

Slag embankments were also found at both ends of SH₂. The embankment to the west was almost round. Its fill was similar to that of the western embankment linked with SH₁, although it had more charcoal and ore mixed in towards the base. This mound of slag overlay ore stockpile 1. The embankment to the east was oval. The fill was like that of the eastern mound linked with SH₁, and the interpretation is the same. Stratigraphically, this overlay the charcoal stockpile and ore stockpile 3.

Production Zone and Stockpiles of Raw Material

A roughly oval charcoal stockpile was identified in the eastern part of the production zone. Its fill consisted of pieces of charcoal and there were two phases. It underlay ore stockpile 3 and the eastern mound of slag linked with SH₂.

Three ore stockpiles were identified. A square pile (1) was in the western part of the production zone, below the western slag mounds and above ore stockpile 2 which was in the middle of the production zone. Stockpile 3 lay in the eastern part of the production zone. This partly overlay the charcoal stockpile and lay beneath the preparation zone associated with SH₂.

Furnaces and Furnace Zones

Furnace 1

Parallel with and up against SH₁ to the south there was a rectangular cut feature which is interpreted as a tapping channel. The channel was filled with the compact layer of crushed tapping slag and some broken shaft material. It was

(see Fig. 3.15). The fill of the pit was loamy sand with slag and ore at the top, while there was a 10 cm-thick layer of roasted ore at the bottom.

Furnace 2

An equivalent tapping channel lay parallel to SH2. The fill of this channel consisted of a compact layer of crushed tapping slag, mixed in with some sand, ore and broken shaft material. The tapping channel was deepest in the centre. Here, too, the slag lay in such a way as to allow two directions of tapping to be determined, away from the middle of the channel. The furnace shaft was poorly preserved, but individual fragments allow the internal diameter to be estimated at about 30 cm.

Below the remains of the shaft, a stone-lined pit with internal lining had been constructed. Parts of the base slag were still in place at the top of the pit. The position of the base slag implies that the fill below it had not been disturbed since the end of production. This consisted of sintered slag, imperfectly reduced fill, ore, charcoal and sand. At the bottom there was a 25 cm-thick layer of roasted ore. The pit had an internal diameter of 25 cm and was 60 cm deep. The tapping slag had flowed down between the stones and the wooden lining in successive waves, as the slag was in several horizontal layers.



FIGURE 3.15 *Jfjp.20: furnace 1. Isolation pit viewed from directly above. In the left-hand pit edge are clear impressions of staves in the slag*

PHOTO: O. TVEITEN, MCH

Roasting Place

A rectangular roasting place lay directly to the south-west of the production zone. This was located on ground sloping slightly towards the south and its fill was red-brown to light red powdered ore. The ore was also mixed in with a little charcoal in the middle. The limit to the south was marked by several head-sized stones closely spaced in a row. The interpretation as a roasting place is based upon its position outside the production zone, the higher presence of charcoal towards the middle, and the heat-affected stones.

Traces of Occupation

Five metres east of the production zone was a roughly square structure consisting of fire-cracked stones and light grey-brown charcoal-mixed sand (Fig. 3.16). The stones lay in clusters to the east and in a belt running east-west to the north, and above a patchy, light grey-brown layer of sand with some admixture of slag, ore and charcoal, which is interpreted as a floor layer. The floor layer lay inside the lines connecting three larger flat stones of about 60 cm diameter which formed a right angle, east-west and north-south. These stones are interpreted as corner pads. The south-western corner was missing, but the ground was damaged by the lifting of several stones. The building had measured about 5.8×6.0 m. Two fireplaces were found in the middle and the fire-cracked stone that lay primarily out by the walls is the waste from these. The fireplaces consisted of dark brown charcoal-mixed sand and fire-cracked stone, mixed in with burnt bone and small pieces of slag. Some larger stones had been used as edging.

Charcoal Pits

Fifteen charcoal pits can be securely associated with the site. All of them were examined, and all were square. In four pits the wood had been laid in a single direction while one had pieces of wood laid crosswise. In terms of the volume of iron extraction at the site, the number of charcoal pits is low, and several of them must then have been reused several times, even if this is not demonstrable from the direct archaeological evidence. There is also a cluster of charcoal pits somewhat further off to the north. The distance, however, is not too great for these pits also to be regarded as part of the ironmaking at this site.

Wood Species and Dating

Eight charcoal samples have been identified as pine and seven of these have been dated. A further dating was taken from burnt bone from the hearths in the building. The probable period of use is AD 1100–1200 (see Ch 5, The period of use and phasing of bloomery site Jfp.20).



FIGURE 3.16 *Jfp.20: remnants of a building with corner stones and fireplaces*
BY H. DAMLIEN/B. RUNDBERGET, MCH

Finds

An iron hook was found north-east of the production zone (C54021/1) (Fig. 3.17). This was square in cross-section and it had a pointed tang. It was 23 cm long, 1 cm wide and 1 cm thick. The length of the tang was 8.5 cm. The same type of object has also been found at Jfp.6 and Jfp.30, and such hooks were probably used to clean the sides of the furnace and the furnace and tapping holes.⁵⁷ The left arm of a horseshoe (C54021/2) was found in the building. This horseshoe is characteristic of the Middle Ages, with a corrugated exterior left by spikes that had been knocked out and three, rectangular, sunken nail holes. The arm narrows towards the end and terminates in a hook at the very end. This type was in use from the eleventh century to the fifteenth.⁵⁸

⁵⁷ E.g. Englund (2002) 130.

⁵⁸ Gansum (2002) 31.



FIGURE 3.17 *Slag hook for cleaning furnace walls, tuyères and tapping holes*
PHOTO: M. TEIGEN, MCH

Burnt bone was found in both fireplaces. Two fragments were identified as cattle and one as pig. Forty-four fragments could be identified as mammalian.⁵⁹ In addition, in the middle of SH1 an unburnt jawbone with pig's teeth was found.

Interpretations of the Ironmaking Site

This ironmaking site is a classic example of the Hedmark tradition. It consisted of two, oblong, parallel slag heaps with tapping channels lying parallel, in relation to each of which the furnace had stood in the centre. The tapping and the positioning of the furnaces in relation to the slag heaps indicates that the bellows had been placed at a right angle to the slag heaps, within the production zone. The eastern embankments are interpreted as processing sites. NIKU's description of the shed relates to the slag mounds which were interpreted as ruined walls before they were uncovered. However, no signs of buildings were found in the production zone.

This site may have two phases of use. Phase 1 is represented by furnace 2 and SH2 with its associated slag mounds. The charcoal store was used for production in both furnaces. The earliest phase of the charcoal stockpile can probably also be linked to the use of furnace 2. The hearths very probably belong to this phase. Phase 2 is represented by furnace 1 and SH1. The later phase of the charcoal store belongs to this phase. From the size of the slag heap, this was the most productive phase. The stockpiles of ore are undated. Stockpile 2 must stratigraphically be attributed to the earlier phase. The floor layer in the building is dated to a late phase, while the hearth is dated earlier, meaning that the building was used throughout the period of activity.

59 Hufthammer (2005).

The Slag Tapping Furnace of the Gråfjell Area—A Distinct Method

The studies show that the slag tapping furnace is the sole type in the Gråfjell area, with the exception of one site dated to the Early Iron Age.⁶⁰ At all excavated sites apart from Jfp.18, the furnace type is the same. At Jfp.18 too, slag tapping was practised, but the form of the furnace was different. The site is dated earlier than other bloomeries in the region and will be discussed in due course (see Ch. 8, The Hedmark tradition in time and space). As the examples show, the furnaces were constructed of two principal components: the clay shaft and a pit beneath it. The pit was constructed within a cut feature below ground level, and the shaft stood as a superstructure directly above the pit at the surface; in some cases the shaft was in fact constructed partly below the surface (see, for example, Jfp.16). The furnace always stands close to the slag heaps, and usually they are constructed in an oval or oblong hollow that runs parallel to the slag heap. No furnaces have been found more than 1 or 2 metres from the slag heaps and the connection between furnace and heap is certain.

The Construction and Form of the Clay Shaft

The furnace shafts are generally poorly preserved, although in some cases the bottom has survived. In most cases, however, the shaft material is found as a layer of red-fired clay close to the original position of the furnace. Clay layers that are not found in association with furnaces have been interpreted as stocks of burnt clay to be used in tempering new shafts. Ceramic analyses, however, reveal no sign of burnt clay being used in tempering; crushed mudstone/shale was, however, used for this.⁶¹ Shale is very similar, morphologically, to the burnt clay, both in form and colour. Whether or not burnt clay was used in building shafts has now to be regarded as uncertain, but it cannot be ruled out as relevant analyses have been carried out at only seven sites.

In many cases, larger pieces of shafts were found in slag heaps (Fig. 3.18). Most of these are curved and show that the shafts were circular. In some cases, however, quite large fragments have been found with little if any curvature. These fragments have something in common with what were interpreted as straight furnace walls at Rødsmoen.⁶² All of the incompletely preserved furnace shafts were rounded, and the degree of curvature reveals that the cross-section was circular. The best-preserved shaft was found at Jfp.3, production site 1 (furnace 2, see above). Both the circular shape of the shaft and the thickness of

60 Risbøl et al. (2002a) 44.

61 Grandin et al. (2005); Andersson et al. (2006).

62 Narmo (1997).



FIGURE 3.18 *A large fragment of a clay shaft found at Jfp.2. The outer side is burnt red and it has been strongly affected by heat and sintered on the inner side. The tapping slag right through the most oxidized zone is probably a blocked tapping hole. Below this, parts of the furnace have been lost, possibly because the tapping cones have been removed and they had partly melted together*
PHOTO: M. TEIGEN, MCH

the body could be recorded with certainty. Remains of the tapping hole were still preserved, and the tapping plates outside the shaft demonstrated tapping in two directions. Inside the shaft wall there were still pieces of the base slag. The internal diameter was measured at 38 cm. Clay had flaked off the exterior, and the outer diameter had probably been 60–65 cm. Only the lowest 25 cm of the shaft remained, and it is unclear how tall the shaft originally was. We have, therefore, to rely upon earlier studies and experiments. An adequate height for slag tapping furnaces at Dokkfløy is proposed to be 70 cm.⁶³ From the similarity in the size of the diameter of the shafts, this can be applied to the Gråfjell area too. It is also a general rule that the height of the shaft should be twice the width above the tapping hole.⁶⁴ Both internal and external diameters at sites where parts of the furnace shafts were preserved correspond with furnace 2 at Jfp.3. The internal diameter varies from 32 to 45 cm and the external diameter from 55 to 75 cm. The external diameter has to be reckoned as a minimum value as flaking has been observed at several sites. On this basis, I would argue that the height of the shafts was 70–90 cm.

Ceramic Analyses

Ceramic analyses were undertaken by Ole Stilborg at the University of Lund.⁶⁵ The shaft material has been examined by eye, with a microscope, and by full chemical analysis. The clay is considered to be local, and the coarseness and composition of the fabric varies. The shaft material from the eastern areas (Jfp.13, Jfp.32, Jfp.33 and Jfp.34) has coarse clay and no tempering. The ware from Jfp.29 and Jfp.23, which are located in the southern part and west of Jernskallen respectively, consists of some smaller grains. The site which stands out is Jfp.8, with very finely grained clay.

The ware from Jfp.8, Jfp.23 and Jfp.29 is tempered with mudstone/slate, probably because of its poor thermal properties. This was worst at Jfp.8, and is reflected in the smelting point. For the eastern group this lies above 1350°C, for Jfp.23 and Jfp.29 below 1350°C, and at Jfp.8 below even 1250°C. The temperature in places will have been above 1400°C, and shafts with such poor properties will have melted down. It is interesting that at Jfp.8, indeed, the shaft of furnace 3 had melted down so that the slag streamed out over the ground and down into the pit.

The pattern of REE (rare earth elements) in the complete chemical analyses proves the clay to have been local. This is reflected in identical clay samples

63 Jakobsen et al. (1988); Narmo (1996a) 77.

64 Grandin and Hjärthner-Holdar (2003) 403.

65 Grandin et al. (2005); especially in Andersson et al. (2006).

and shaft material from Jfp.29 and also through general similarity between ores and clay.

External Formwork and Isolation

On the outer side of the clay shafts, at several sites a thin rim of charred wood chips or shavings was found. This was found down towards the ground surface and always faced into the production zone or out towards the slag heap. The wall of wood chips is not found on the sides where the slag was tapped out. Wood-anatomical analyses show that the material was thin wood shavings or bark. The thickness of the shavings ranged from 2 to 5 mm and the wall was constructed of square or rectangular pieces in several layers. The wall of shavings around the shaft of furnace 2 at Jfp.8 was best preserved. Here, it was possible to see three layers that had been bonded vertically-horizontally-vertically. The height of the wall of shavings was at most 8 cm. Outside this wall there was also found a thin wooden band of a flexible twig whose function was to hold the packing of wood chips in place. Wood shavings also surround other furnaces and the method appears to have been a standard practice.

The wall of wood chips probably surrounded the entire shaft, and its absence from the tapping zone is due to it having been burnt away. Its purpose was probably to serve as a formwork when building the furnace shaft. Other forms of lining or outer insulation of the furnace shaft have not been identified archaeologically, except insofar as the furnace in some cases was sunk into the ground in places. The shafts are therefore taken to have been circular and free-standing, with walls 15–25 cm thick.

The Isolation Pit—The Unique Feature of the Tradition

In the Gråfjell area, one element appeared with the furnaces that had not hitherto been noted in the archaeological literature: a substructure beneath a slag tapping furnace. This phenomenon is not completely unknown, however, as previously these had been found at some sites (see Ch. 2, Slag tapping shaft furnaces in Norway). The problem has been the interpretation, affected by a lack of parallels in other known evidence.

Immediately below the clay shaft, a ring of stone edging that served as a foundation for the shaft was constructed within a pit. Outside the stone edging the pit was partially refilled, while the upper part was used for tapping. Within the stone edging, a lining of wooden staves was constructed. Each stave was pointed at one end and driven in to the base of the pit. The lining ran up some way into the clay shaft. How high the staves stood is uncertain, but in furnace 2 at Jfp.3 it is clear that it was well above ground level (Fig. 3.19).

The lining was constructed with great precision, and this task was time-consuming. An important principle with the wooden lining was that the staves should stand closely together and not just be made out of randomly selected wooden sticks (Fig. 3.20). The reason for this is probably that nothing was meant to be able to pass in or out through the lining. From the construction of the furnace it is likely that the lining would prevent slag from flowing into the pit. In many cases, the slag being tapped out had flowed down between the stones and set between the stone edging and the lining. This slag lies in several horizontal layers and thus bears witness to tapping out in portions. The lining has been charred but stood firm and the slag was stopped by it.

The staves may also have served as a primary framework when the furnace shaft walls were being built, although the staves that continue into the shaft at Jfp.3 are the only secure evidence of this function, apart from one shaft-fragment with an impression of wood. An additional function that was not necessarily intended but was more a by-product of the construction is that the staves perforated the base slags. The base slag that accumulates during the ironmaking process can reach a thickness of more than 20 cm. It surrounds



FIGURE 3.19 *Section through the isolation pit belonging to furnace 2 of Jfp.3. At the transition between the pit and the shaft there is slag which shows that the staves protruded some way into the shaft*

PHOTO: B. RUNDBERGET, MCH

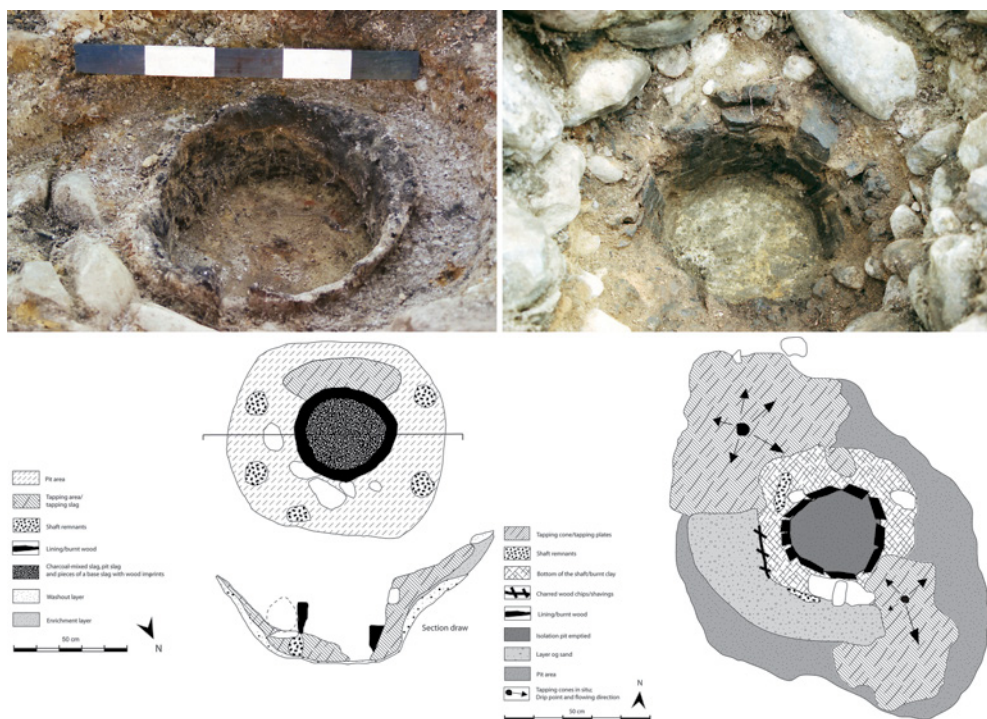


FIGURE 3.20 *Excavated isolation pits showing construction of the pit stonewall, the wood lining inside and tapping direction. Top left, Jfp.12, furnace 1; top right, Jfp.11, furnace 2; bottom left, Jfp.1, furnace 2; bottom right, Jfp.14, furnace 2*
PHOTO/DRAWING: MCH

the staves against the wall, producing a porous slag which is relatively easy to remove when cleaning out.

In contrast to the pits of the Early Iron Age, slag collection was not the function of the pits. This is shown first by the fact that these were slag tapping furnaces (Fig. 3.21). No pits with slag or lumps of slag have been found. The lining is also a feature which implies that that was not the process, since this was constructed, amongst other things, in order to keep the slag out of the pit.

At the junction between the pit and the shaft lay a base slag which forms the bottom layer in the part of the furnace in which reduction took place. The base slags are heavy, dense, and of dark, variegated colours. Small, rust-red iron flecks are often present. They have rounded sides, from the shaft, and the upper side ranges from concave to more or less flat. The underside varies in shape but is affected by the underlying fill. Impressions of wood from the lining can often be seen in the sides of the base slag. Archaeometallurgical analyses show that



FIGURE 3.21 *Jfp.28: the isolation pit belonging to furnace 2 has been excavated. To the left stands a tapping cone, untouched since the last tapping. A matching tapping zone lay to the right of the furnace, but had been removed when the photo was taken. The remains of the furnace shaft are visible as reddened clay*
 PHOTO: U. GRØTBERG, MCH

this is a coarse-grained, homogeneous slag which has formed gradually. Scattered through the slag is iron in small concentrations, and often round pieces of charcoal which have been surrounded by the slag.⁶⁶ In the bottom layer of the slag sand, charcoal, fragments of slag and roasted ore appear. This is a mass that has sintered but not melted and set together, and it matches what is found in the pit below: charcoal, ore, gravel, sand and slag. The sintering had happened at an early stage in production. The slag that is found in this mass is from an earlier reduction. It consists overwhelmingly of minor pieces of tapping slag.

The pit had a key function. This is evident in its careful construction. I know of no parallels in the evidence for European bloomery ironmaking, and its function must therefore reflect the particular method here. It probably served several practical purposes. One proposal is that it acted as a barrier to damp.⁶⁷ However, the sites in the Gråfjell area are usually located on dry morainic

66 Espelund and Nordstrand (2003); Grandin et al. (2004), (2005); Andersson et al. (2006).

67 Espelund and Nordstrand (2003).

ridges with good drainage. During excavation, the problems of a high water table were rarely encountered.

A more plausible explanation is connected to the need for isolation. No form of external insulation has been identified. A pit below provides an 'under-insulating' effect to prevent the base slag setting too quickly. A warm pit may also have assisted a better flow during slag tapping as the ground immediately around the furnace was warmed up. The pits are therefore referred to from here on as *isolation pits*.

For copper smelting, comparable isolation pits have been identified, in Israel for instance,⁶⁸ while in the historical period (1600–1900) isolation pits were common in European iron production.⁶⁹ There is a parallel in the Japanese Tataru technology.⁷⁰ The Tataru technology has its roots back in the Late Iron Age. It consists of two principle components: a furnace shaft above the ground and a pit beneath it. The pit is filled with charcoal and ash (called a 'charcoal bath') and the function of the pit is isolation and to prevent damp. The slag is tapped from a certain height and flows very freely. The furnace was demolished after production and the bloom was removed at the end. The Tataru technology is particularly famous for producing the steel for the famous Japanese Katana swords.

There is no direct relationship between the Tataru and the Gråfjell furnaces, but there are several shared elements, and the technology may have had a wide distribution, albeit in different forms. At Tæbring on Mors, a slag tapping furnace from the eighth century has been excavated. Beneath the furnace shaft, a thick layer of charcoal was found in a small hollow. The interpretation of this feature is that there was a charcoal bath⁷¹ as in the Tataru process, to insulate against the cold and damp ground.

Tapping Slag—Flowing Slag

The typology of slag has been introduced ahead of the review of the evidence. Here I shall discuss the subject a little more thoroughly. The usual practice is that a narrow channel is made leading from the furnace at ground level. When tapping out, the slag consequently takes the form of ribbons of slag and is therefore referred to here as 'flowing slag'.⁷² The slag in the Gråfjell area, and also at Rødsmoen, is of a different character. The slags may take a variety of

68 Hans-Gert Bachmann: lecture at 'Archaeometallurgy in Europe 2011', Bochum.

69 E.g. Karsten (1831).

70 E.g. Tylecote (1976); Inoue (2010).

71 Pers. comm. Jens Jørgen Olesen, 19 March 2012.

72 E.g. Martens (1988); Larsen (1991), (2004); Narmo (1996a).

styles, with the conical form being characteristic. To distinguish these from the rest of Norway, the term 'tapping slag' is used for this tradition.⁷³ A regular feature in this area is that the slag has been tapped from a certain height, down along the wall of the shaft. This took place in several stages, with the slag setting either fully or in part between tappings. The process led to the accumulation of a series of layers and the result is what I refer to as 'tapping cones'. The tapping cones have the form of a half-cone because they flowed down the shaft wall. Finds of tapping cones weighing tens of kilograms indicate that one production process could continue over a long period of time, and that blooms may have been extracted several times during that process.

Tapping slag, however, may also take the form of tapping plates. These are the extensions of a tapping cone over the level ground. The flowing structure is often thicker and, wider, while in some cases the upper surface is completely smooth. Tapping plates are the remains of production which are most often found around the furnaces.

The isolation pits were usually placed in an elongated or oval cut feature on the same alignment as the slag heaps. The channels were adapted to the method of production involving the tapping of slag from a certain height, and are referred to as 'tapping channels'. The tapping channels were partly constructed, partly the product of repeated tapping. They are widest, deepest and longest at sites with large slag heaps, and can be associated with long-term use and a high number of tappings. With the cleaning out and removal of slag, more of the earth around the channels would have been removed too. The heaps were extended at the ends, and the removal of the slag was done by raking the slag out of the furnaces towards the ends before it was put in the heaps.

Another feature which points to the gradual digging out of the tapping channels is the presence of tapping cones of different heights at the same production sites. The fall becomes greater with a deeper channel, and short tapping cones can be connected with early phases of production. A key point with deep tapping channels may be the desire to undertake production at considerable intervals of time without needing to remove the slag.

In some cases, no tapping channels have been identified, and the methods of slag tapping at these sites vary. It may be tapped into the circular or oval, sloping-sided cut feature in which the isolation pit is set. Small tapping pits around the furnace have also been found. The latter are exceptional, but the use of the hollow as a tapping pit is fairly common in the evidence. In all of these cases the pits had filled up rapidly, and the slag had flowed out over the original ground surface.

73 Rundberget (2007) 326.

Air Supply

The finding of an iron mouthpiece from a bellows (C52708/1) at Jfp.39 shows that a draught was provided by using bellows (Fig. 3.22). This mouthpiece is the only example of this type to have been found in Norway although a counterpart has been found in Lima, Sweden.⁷⁴ Beside several furnaces there were also signs of bellows in the form of distinct features, bases of sand and stone. No signs of post holes have been found, and the structure in which the bellows was suspended sat on the ground. As the evidence points to parallel or overlapping work in two furnaces, the structure must have been movable. At Jfp.23, beside furnace 1, an iron ring and iron rod in two sections were found (C54040/1). The rod had been fastened to the ring at one end. The outer section has a hook at one end (Fig. 3.23). The context implies that this may have been part of an articulated suspension chain for a bellows, with the ring threaded over a bar crossing over the top.

There is little evidence of the bellows themselves in the archaeological find material, although the usual view is that pointed bellows were used. This type is known in several contemporary or earlier images, such as on the Hylestad doorway (Fig. 3.24). It is, however, a matter of uncertainty whether one



FIGURE 3.22 *Tuyère (C52708/1) found in a slag heap at Jfp.39. This consists of a rolled and slightly bent iron plate. It is a bit encrusted with slag at the end which was placed in the wall of the furnace*

PHOTO: M. TEIGEN, MCH

74 Matsson (1982) 173.



FIGURE 3.23 *Artefacts found at Jfjp.23. Left: hook/suspender of iron (C54040/1) found immediately adjacent to furnace 1, possibly part of the suspension of the bellows. Right, upper: a sewing needle (C54050/2). Right, below: burnt bone fragment/fragment of bone comb with a bronze rivet through it (C54040/10)*

PHOTO: M. TEIGEN, MCH

double-pointed bellows or two single-pointed bellows were used.⁷⁵ To judge by the space regularly required at ironmaking sites and the size of the bases, I consider it to be most probable that a double-pointed bellows was used. The bellows was placed between the stockpiles of raw materials and there was working space on either sides of its suspension frame.

Towards a Definition

The furnace of the Gråfjell consisted of a clay shaft with no exterior insulation and the technology is thus clearly different from contemporary Norwegian bloomery ironmaking elsewhere. The type of furnace is probably to be classified within the group of *Small free-standing thin-walled shaft furnaces*⁷⁶ (see Ch. 2, The slag tapping furnace in Europe and Scandinavia) but the furnaces also had their characteristic isolation pit whose function was manifold (Fig. 3.25). Tapping out was carried out from a certain height down into a tapping channel or tapping pit. The reason for this was a desire for long-term use with no unnecessary breaks in production. The furnaces therefore had a shape that allowed for intensive use and thus a high volume of production and profitability, something which, to judge by the number of sites and the level of production, can be assumed to have been a primary objective. From its morphology and the process, I would therefore characterize the furnace as a free-standing,

⁷⁵ Narmo (1997) 123.

⁷⁶ Pleiner (2000) 173.



FIGURE 3.24 *Part of the Hylestad doorway from Valle in Aust-Agder. Here, Regin is forging a sword for Sigurd Fáfnir's-slayer, for the battle with the serpent Fáfnir. An assistant is working the bellows*

PHOTO: MCH

thin-walled, under-insulated, slag tapping furnace from which the production of a surplus was the principal aim.

Unexcavated Bloomery Sites

Building upon the knowledge gained from the excavations, it is possible to identify clear patterns at unexcavated sites too. It is thus possible to classify and interpret even the ironmaking sites that were not included in the analysis for the excavation report.⁷⁷ This applies to a total of 31 production sites (see Ch. 3, Bloomery ironmaking in the Gråfjell area—form and facts). All of these sites were inspected as part of the selection process and their most prominent features were documented. Key details were form, type, size

⁷⁷ Rundberget (2007).

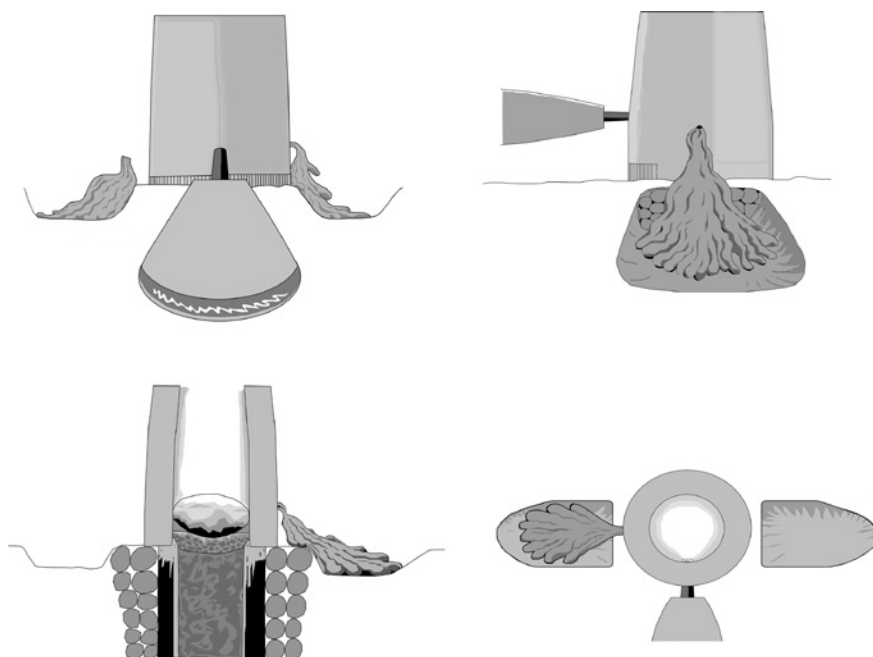


FIGURE 3.25 *The furnace drawn from cross-section measurements and according to interpretation of morphology and activity. Upper left: the furnace seen from the production zone, with the bellows in front. Tapping is done alternately in two channels or pits. Upper right: the furnace seen from the side with tapping holes and channels. Lower left: section through the furnace seen from the production site. The figure shows the structure and relationship between shaft and pit. At the bottom of the shaft can be seen the base slag and the iron bloom. Lower right: the furnace viewed from above*

BY R. BORVIK

and the number of slag heaps. In some cases, the furnace morphology was described as well.

Of these sites, 29 were classified as the 695-type. Two ironmaking sites were recorded as hybrids of the 695- and 300-type. This ratio is to be expected, as small and untypical sites were prioritized for investigation, including all of the sites that were not of the 695-type. In the inspection phase, the objective was to select sites for excavation with reference to type, size, preservation, geographical location and accessibility. For these reasons, several sites were judged not to be suitable for excavation, while others certainly could have been included in the programme.

Of the 29 sites recorded as 695-type sites, 23 had two parallel slag heaps with the distance between the slag heaps varying from 6.2 to 10.9 m. The mean value

was 6.6 m and this stands comfortably within the normal range. One site with two slag heaps is organized differently as it has one elongated and one round slag heap. The distance between these slag heaps is only 2 m. Four ironmaking sites had only one elongated slag heap, one site was recorded with three slag heaps and two with four. At these sites there were both elongated and round slag heaps.

During NIKU's survey work, most attention was paid to slag heaps in terms of classification and organization. The remains of bloomery sheds were also identified. The furnace zones and raw material stores were not recorded. Using the results of excavation, it is possible to expand the picture and also to discount elements at several sites. There is a summary assessment of all the unexcavated sites in Appendix Ib.

Description and Interpretation

The unexcavated ironmaking sites are a key plank in the study of the evidence as whole. Both technological and organizational features can be traced, while the sites are an essential component in statistical analyses. As appears from Appendix Ib, there are changes in interpretation from recording to inspection. This can partly be attributed to subjective perception, but in fact the basis of interpretation developed too, and elements that were not identified in NIKU's survey work can be included in an analysis on the basis of relevant excavated evidence. In this case, it is the particular elements of the positioning of the furnaces and the overall organization which both expand and correct the survey results. The morphological character of the slag heaps provides important information on the volume of production. Small, round heaps are evidence of smaller-scale production than the large elongated ones, while, for example, curved slag heaps or slag heaps with extended projections at the end point to a state of organization in which it is not possible to identify definite production zones.

The slag itself is fundamental. In combination with a typological scheme, the distribution of visible pieces of slag is able to contribute to more precise conclusions about positioning. The slag is also the most important factor in the interpretation of the furnace type at unexcavated sites. Here, the slag provides clear evidence that the structure of the furnace at these sites was of the same basic type. Furthermore, some pieces of slag could provide information, from their size and height, on long-term or intensive use.

The extent of production is an important feature. I have elected to use NIKU's recorded figures in calculation, as these do not diverge from the results of excavation any more than might be expected. The volume of the slag heaps is calculated, and included in the statistical analysis that shows the quantity

of production in the Gråfjell area (see Ch. 6). Mapping is also a key stage of the analysis. Location and size are factors to which particular importance is attached, and these are discussed further in Chapter 3.

One further detail that has been studied is organizational relationships, a point which introduces what is discussed next. During inspection, one aim was to identify the different main components. In those cases where this was achieved, a good view of organization was obtained. The furnace zone could be identified in the majority of cases, and in some cases the stockpiles of raw material were identified by coring. The organization could thus be determined more or less directly, if one excludes aspects such as possible phasing and the number of structures. In cases where only the slag heaps could be seen and no coring was undertaken, it was possible to guess at the organization from the form of the slag heaps and their position relative to one another. Altogether, this has allowed me to define all of the unexcavated sites, a definition that I shall expand upon below.

From Concept to Symmetrical Organization

As is revealed above, the ironmaking sites in the Gråfjell area display considerable similarity in form. There are variations, but these are primarily related to differences in the level of production from site to site. With this as the general view, I shall now make a short summary and develop a model within which I believe *jernvinna* in this area can be situated.

Classification

The results of the archaeological investigations in the Gråfjell area are manifestly different from those from the Rødsmo Project, with its 695- and 300-types. In classifying the ironmaking sites in the Gråfjell area, I have attended primarily to the relative positioning of the main components. In practice, that involves the stockpiles of raw material, the furnace zones and the slag heaps. The number of components is directly related to the complexity and form of the site. An element which also creates variance in organization is the local topography, and this is taken account of in the discussion.

As I interpret the evidence, the organization is based upon a principle that I define as a 'basic model'. The basic model consists of four components: a furnace, a stock of charcoal, a stock of ore and a slag heap. Together these form a composite site that schematically is like a hare-trail, in which the slag heap and the furnace are the front paws and the stockpiles of raw material the hind paws (Fig. 3.26). This form corresponds closely with the Rødsmo 300-type, except

that the slag heaps can be of varying form. The organization was *not* static, as there are variations with respect to which side of the furnace the stocks of raw material were placed, while their distance from one another and distance from the furnace also varies. Key to this relationship is that there was sufficient room for the essential activities. This relates in the first instance to room for the bellows, an area for tapping out, and general workspace. The stocks of raw material thus could not be too close, even if they were placed right beside the furnace. If they were further off, it would not cause any problems.

Divergence from this form of organization does occur, but only in one definite case. This is the Merovingian Period site Jfp.18, where the two stockpiles of raw material were laid down successively on the same side of the furnace. At Jfp.18, variation in furnace type was also identified. The absence of an isolation pit and thick layers of burnt clay imply a somewhat different structure from that which was the norm in the late Viking Period and Middle Ages. I consider Jfp.18, with its early date, to belong to an earlier tradition, and the organization is therefore somewhat different from what the rest of the evidence shows. But a tapping technology was practised, showing that this method was known as early as the seventh century. Jfp.18 appears more or less contemporary with

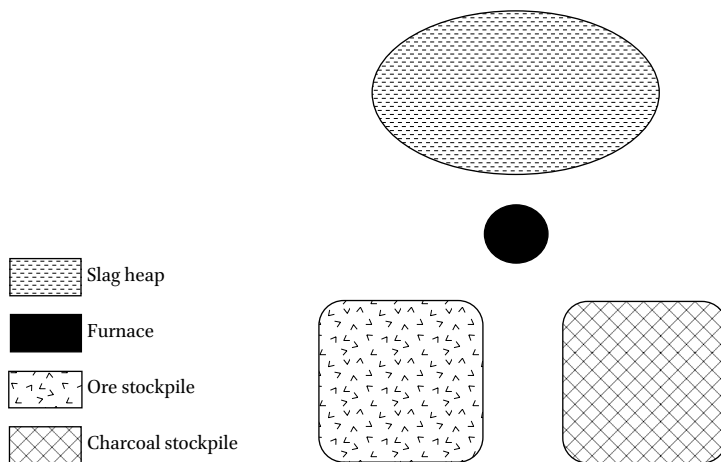


FIGURE 3.26 *Schematic representation of the most important components of a phase of use at the ironmaking sites of the Gråfjell area (not to scale). This form is called the basic model, but should not be treated as something static. There is no fixed rule for which side of the furnaces the charcoal and ore stockpiles were placed. The size of and distance between the components also varies*

BY B. RUNDBERGET, MCH

the small bloomery furnaces with slag pits at Rødsmoen.⁷⁸ This was a period of change with respect to technology, and both types of site are crucial to the development of the technology in the Hedmark tradition.

With the exception of Jfp.18, all of the ironmaking sites have manifest similarities in organization. The sites presented as examples demonstrate this. They were therefore not selected because they are special but rather in order to foreground what can be referred to as 'average' sites. The plans clearly show a basic organization, and it is the complexity that introduces variation. This is the case with all the sites dug, and also for those that were not excavated. Variation is therefore inferred to depend upon size rather than upon form. The volume of production illustrates the picture of variance well, as the largest excavated site, Jfp.30, had produced at least 110 t of iron, while the smallest (Jfp.7 and Jfp.35) had an aggregate production of under one t (see Ch. 6, The volume of iron production).

Variation is, on this basis, expressed in terms of the numbers of furnaces, slag heaps and stockpiles of raw material at each production site, and also of the number of production zones and production sites at each individual bloomery site. As correspondence in position between furnaces and slag heaps seems to be practically standard, I start from the visible slag heaps.

On the basis of the components, it is possible to deduce the organization of the individual sites. The basic model with one furnace and associated components has been found by excavation in nine cases, and there are also two of the unexcavated sites which are identified as being of the same form (see Appendices 1a–b). In most of these cases, production was limited in comparison with sites with several slag heaps. The highest level of production was at Jfp.10 where the quantity of slag is calculated as 9.5 t. But Jfp.4 and Jfp.16 also had relatively high production with 5.0 and 2.5 t of slag respectively. Considering location, it is evident that the sites with one slag heap lie in the north-west, and west of Malmmyra.

Variations in organization are constructed from the basic model, and the most common organization encountered is referred to as the 'standard model'. At such sites there are two furnaces with associated slag heaps, and separate stockpiles of raw material. The standard model can be said to be the basic model doubled in a mirror image along an axis formed by the stocks of charcoal and ore so that the furnaces and slag heaps lie directly opposite one another on either side of the stockpiles (see Fig. 3.28, Tab. 3.4). Bloomery sites Jfp.3 and Jfp.20 are typical examples of the standard model. Altogether, 20 of the excavated sites and 25 of those unexcavated were of this type. The form has clear parallels

⁷⁸ Narmo (1997) 116.

with the 695-type, which is also considered to be a standard,⁷⁹ although the slag heaps are not necessarily elongated. They can be round, curved or angular. Looked at in terms of the principal components, there are also differences between the 695-type and the Gråfjell evidence as the furnace in the Gråfjell area is found close by the slag heaps while that at Rødsmoen is understood to have been situated somewhat further into the production area.⁸⁰ Locating the furnace on 695-type sites depended largely on the interpretation of bloomery

TABLE 3.4 *The organization of ironmaking sites in Gråfjell based on the four components of furnace, charcoal and ore stockpiles, and slag heaps (see Fig. 3.28, cf. Appendices 1a–b)*

Organization	Description	Number of sites
<i>Basic model</i>	Consists of four components: A furnace, a stock of charcoal, a stock of ore, and a slag heap. Schematically is like a hare-trail, in which the slag heap and the furnace are the front paws and the stockpiles of raw material the hind paws (Fig. 3.25).	9
<i>Standard model</i>	The basic model doubled in a mirror image along an axis formed by the stocks of charcoal and ore so that the furnaces and slag heaps lie directly opposite one another on either side of the stockpiles (Fig. 3.27)	20
<i>Basic and Standard model</i>	Combination of the Basic and Standard models, eventually a combination of two Standard models. Can also be one Standard model and several Basic models.	8
<i>Variation Basic model</i>	Consists of the components in a Basic model, but the stockpiles of raw material were located on the same side of the furnace zone	1
<i>Variation Standard model</i>	Consists of two furnaces and two slag heaps all in a line. The ironmaking site also had two sets of charcoal and ore stockpiles.	1

79 Narmo (1997); Risbøl et al. (2002b).
80 Narmo (1997) 122, Fig. 75.

sheds, and remains of shaft material and/or tapping slag found. The type of furnace was described in Chapter 2, but it has only been indirectly observed and I do not subscribe to the interpretation myself.

A variant in the form of organization involving two slag heaps was found in one case, Jfp.6. Here there were two furnaces and two slag heaps all in a line. The ironmaking site also had two sets of charcoal and ore stockpiles. The internal placement of the components and the type of furnace agrees with the basic model. This is a different form of mirror image around a single line placed at a right angle at the end of the slag heap. In organizational terms it is less logical, although it is to be stressed that production was concurrent and therefore more than one stockpile of raw material was needed. From the stratigraphical relationship, it might appear as if there were a chronological difference, but the radiocarbon dates imply nonetheless that activity was concurrent or overlapping.

The volume of production at sites of the standard model is clearly higher than at those of the basic model: a natural issue, as the sites have multiple waste heaps. In addition, the slag heaps are consistently larger at sites with several furnaces. The largest heaps tend to be found at sites with more than two furnaces.

Sites of the standard form have been excavated over the entire region, and are regularly spaced. What, however, appeared clearly was that the largest sites are to the south while those to the north are noticeably smaller. This phenomenon corresponds entirely with what was found when inspecting the unexcavated sites.

Eight sites with more than two slag heaps have been excavated and the unexcavated corpus includes three sites with three slag heaps. Three heaps have been uncovered at four bloomery sites (Jfp.1, Jfp.14, Jfp.23 and Jfp.37). With one exception, all of these are organized as the standard model plus one basic model. The exception is Jfp.1 which has only one large slag heap together with two small heaps or dumps.

The sites of both the standard model and the basic model have some differences in organization. At Jfp.14, the basic model (slag heap and furnace) lay beneath one of the slag heaps of the standard model. At the other sites, the basic model and the standard model lay side by side. Jfp.37 has not been excavated, but magnetometric survey shows this organization clearly. At both Jfp.14 and Jfp.23, the basic model is interpreted stratigraphically as the earliest. Also interesting is the variation of slag heaps within the basic model. At Jfp.14, slag heap SH3 is relatively small, while at Jfp.23, SH1 is so large that eventually there must have been problems in depositing the material. As a result, it was necessary to move. Why production was ended and moved away from Jfp.14 is less

certain, but it must presumably be based either on a break or in a change of organization that encouraged a move. This is also probably the case with Jfp.37 with its relatively small slag heaps.

At ironmaking sites with four or more slag heaps I assume likewise that internal relocation was required by the level of production. There are exceptions here too, though. Jfp.8 had one large and three small slag heaps, and a relocation of the furnace was caused by a failed process. The three other sites, Jfp.5, Jfp.12 and Jfp.30, were all sites with several large slag heaps which indicate very intensive work. In all cases these comprised one or more standard models. At Jfp.5, there were also four basic models which are stratigraphically and on their dating evidence earlier than the standard model. At Jfp.12, the slag heaps almost formed a square, while the site was also extended with two further slag heaps. The standard model which accounts for two of the slag heaps in the square was established in an early phase in the pause of production. Jfp.30 consisted of two standard models. At this site there was a shift of a few metres to establish a new standard model when the slag heaps became too large for deposition without the danger of slippage.

The unexcavated sites have a form of organization that corresponds closely to this view. On the whole, it is the standard model that is represented, naturally enough when the majority are recorded as 695-type sites with two slag heaps. No site differs from this organizational structure; on the contrary they all conform and support the view that there was a shared model at the heart of iron extraction in the Gråfjell area.

To sum things up concisely, the ironmaking sites had an archetypical basic model consisting of a furnace, stockpiles of raw material and a slag heap. Most common is a standard model that is, as it were, a mirrored basic model with two furnaces and slag heaps lying directly opposite one another. Sites with extra furnaces and slag heaps consist of basic models and standard models or multiple standard models, but all appear, nonetheless, to have been based upon the common organizational concept. There are only two divergent forms of organization in the evidence. At Jfp.18, the stockpiles of raw material were located on the same side of the furnace zone. This site has an early date, as has been noted, and the organization is attributed to that. Jfp.6 differs in that the slag heaps and furnaces lie in a row and not opposite one another.

Compared with Rødsmoen, the result is not significantly divergent. One difference is that a distinction was drawn between the 300-type and the 695-type in terms of the size, form and number of slag heaps. Narmo⁸¹ has subsequently come to the view that this organization was probably derived from the same

81 Pers. comm. Lars Erik Narmo.

concept. The form of the slag heaps was, however, governed by work practices⁸² and has to be looked at in relation to the conditions of production, with elongated slag heaps representing longer and more intensive activity. Sections through the slag heaps show in most cases that they accumulated from the centre out to the sides. A consistent feature is that the large, elongated slag heaps also have the longest and deepest channels. To remove the slag around the furnace a scoop or pick was probably used, like the picks found at Jfp.11 (C53983/1) and Jfp.39 (C52708/2) (Fig. 3.27). After tapping out in two directions, the slag was removed from the furnace area, and on the large production sites it is logical that in building up large heaps one would carry the fill off towards the ends of these before they were raised higher. Several sites also have small heaps at the end of the channels, implying the removal of fill in this direction.

Bloomery Sheds

As an aspect of organization, a major question for research into Norwegian *jernvinna* has been to what extent production took place under cover or whether it was done in the open air. In southern Norway in the Middle Ages, it was normal for production in slag tapping furnaces to have been carried out in a shed while sites from the Viking Period usually have no such shed.⁸³ At excavated sites of this type, the building walls often appear as low banks or can be revealed as thin layers in sections. The furnaces stood beneath a roof but were exposed on one or more sides. The structures were constructed with turf walls⁸⁴ or cogged.⁸⁵ Several of the buildings prove to have had two or more



FIGURE 3.27
*Iron picks found at
ironmaking sites Jfp.11
9C53983/1) and Jfp.39
(C52708/1)*
PHOTO: M. TEIGEN,
MCH

82 See Englund (2002) 22.

83 E.g. Martens (1988); Larsen (1989), (1991); Narmo (1996a); Tveiten (2008); Mjærum (2011).

84 Martens (1988) 80–82.

85 Narmo (1996a) 132.

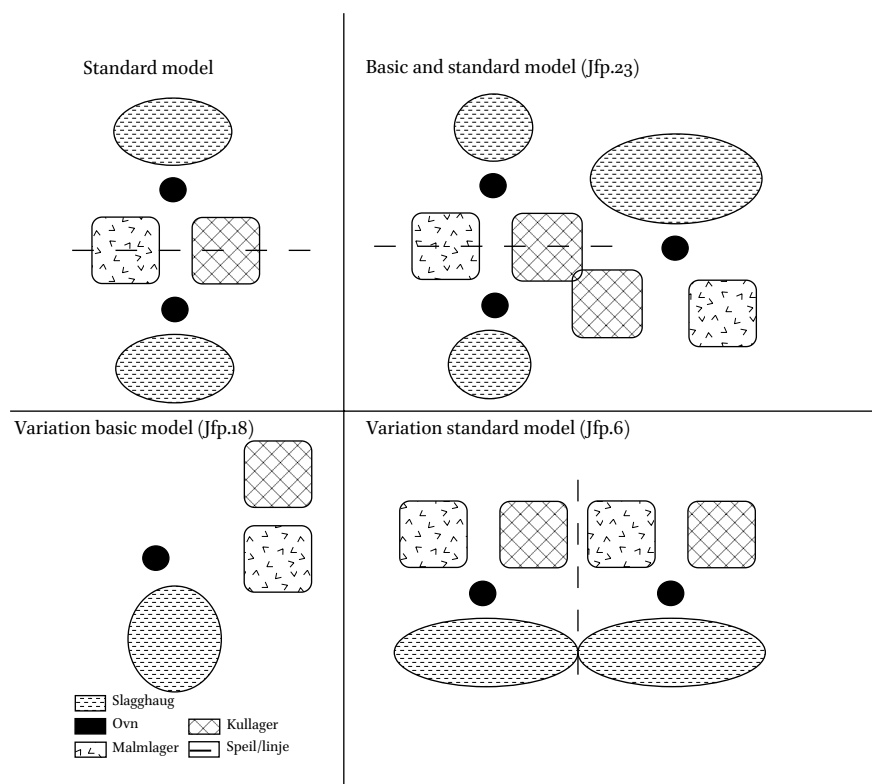


FIGURE 3.28 *Schematic representation of the organization of excavated ironmaking sites. All are interpreted as being based upon the basic model*

BY B. RUNDBERGET, MCH

chambers. The inner room usually has a fire place and was the living area when work was in progress. The living area in the bloomery sheds at Møsstrand has an area of 10–15 m². This implies that there was no permanent occupation.⁸⁶ The buildings at Dokkfløy⁸⁷ and at Tyin at Lillefjell⁸⁸ are interpreted likewise.

At Rødsmoen, no bloomery sheds with banks were found. The 695-type sites with two parallel slag heaps at a fixed distance were, however, interpreted as evidence of ‘something’ that was no longer visible on the surface. It was assumed that the regular spacing was due to some structure.⁸⁹ The background

86 Martens (1988) 124–125.

87 Narmo (1996a) 117.

88 Larsen and Rundberget (2009) 49.

89 Narmo (1997) 65.

to this idea derives from Dokkfloy, where sheds were found that had stood directly upon the ground surface.⁹⁰ The bloomery shed at R695 was not directly visible but is inferred from the limits of the material stores and from two cut features up beside the slag heaps which were interpreted as post holes (Fig. 3.29). The distance between these posts was 8 m, and from the charcoal and ore waste the building was taken to be an open shed with a long open side between the earth-fast corner posts.⁹¹ The furnace with bellows and the stockpile of ore were under the roof while the charcoal stock was in the open. The rear wall and the short walls were cogged, and the pads for the short walls were buried in an irregular cut feature.⁹²

Crucial to this interpretation is a form of organization with a furnace within the production zone. No such bloomery sheds were found in the Gråfjell area, and signs of any buildings in the production zone have been discovered only

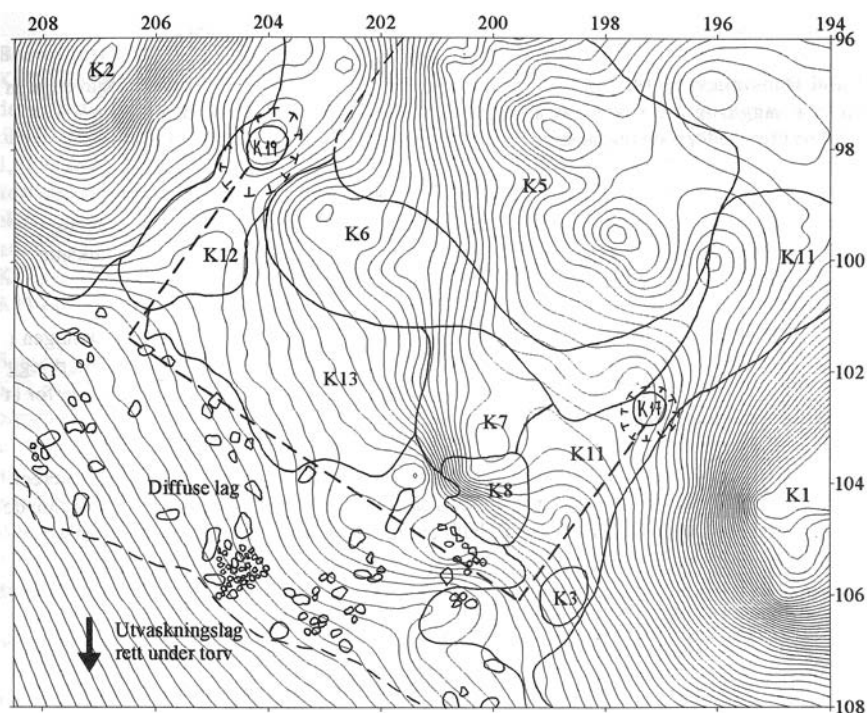


FIGURE 3.29 The bloomery shed at R695, Rødsmoen, deduced from topography, post holes, layers and stones, after Narmo (1997) 67, Fig. 37, MCH

90 Narmo (1996a) 92–117.

91 Narmo (1997) 117.

92 Narmo (1997) 65–67.

at a minority of the excavated sites. In terms of organization according to the basic model, the interpretation of bloomery sheds of the 695-type is also problematic. In the excavation report of R695 at Rødsmoen the cut features are interpreted as possible post holes.⁹³ The fill in these features consisted, at the bottom, of a layer of soil containing charcoal, while the upper layer was disturbed and comprised sand/gravel and crushed slag. In the walls, at the top of both features, there was *in situ* slag which formed a circle. The diameter within the slag was in one case measured at 30 cm. This slag is interpreted as post-packing.

The furnaces in the Gråfjell area were positioned close to the slag heaps and correspond with the post holes at R695. The descriptions from the field reports appear to me to have much in common with the isolation pits in the Gråfjell area. This holds for the form and the fill in those cases where the isolation pits had been emptied, but also for the slag *in situ*. Consequently, I suggest that there is every reason to believe that the cut features at R695 also represent isolation pits from under furnaces. Another feature that suggests this is the cut features which are suggested to have been constructed in order to stabilize the wall beams for the short walls of the shed. These run parallel to the slag heaps and are interpreted as tapping channels in the Gråfjell area.

The straight edges of the stockpile of ore at R695 were interpreted as evidence of a cogged wall. In the Gråfjell area, the ore piles were often oval or elongated, and no clear edges against a wall were seen. On the other hand, it was usual to find little bits of ore waste spread around the storage area. The raw material and activity layers took the form of thick layers covering much of the production zones and the extent of the stockpiles of raw material argues against the idea of a large open shed in the Gråfjell area.

One point in the interpretation was that the roughly equal distance between the slag heaps was a reflex of the traditional use of a shed of a fixed size. The distances between the slag heaps in the Gråfjell area were measured during survey work as from 4.5 to 13 m, albeit with a majority in the range of 6 to 8.5 m. The excavations thus demonstrate quite a wide variation in the distance between the heaps, and I do not regard the distance as a reflection of any shed of fixed size. The distance can be topographically governed, but is by preference to be viewed in purely organizational terms, without having to be associated with any fixed installations other than the furnace itself.

In only two cases have elements been discovered which can be associated with some structure within the production zone. At Jfp.6, eight paired holes lying approximately in a row in an alignment that ran alongside the ore and

93 Johansen (1995).

charcoal stockpiles were found. These have been interpreted as from some light structure which covered the stores of charcoal and ore. The evidence does not reveal if this was roof-bearing, or a box-like structure. At Jfp.16 the impressions of logs from a wall were found beneath both the charcoal and the ore stockpiles, possibly two small bins. The latter is most probable because there was a break in the impression between the two stocks. These structures had been raised to protect the stockpiles of charcoal and ore. Similar structures may have been common, but they have left no traces in the archaeological evidence. No form of covering of the furnace was identified. That, however, was unnecessary, if we suppose that reconstruction at the start of the season was a normal stage of the work, as the furnaces must in all cases have been subject to improvement and repair.

Occupation or Settlement?

At 16 of the 32 fully excavated ironmaking sites, evidence of occupation was found. This consists, for the most part, of fireplaces, although culture layers and low wall banks have also been identified. These were all placed outside of the production zone. Case studies Jfp.3 and Jfp.20 both had two fireplaces, which lay within a culture layer at Jfp.20. The hearths are of a common character. They are mostly round or oval, though they can also be more or less square. The size ranges from 0.9 to 2.5 m. The fill of the hearths is relatively homogeneous, consisting of sand mixed with charcoal and fire-cracked stone. A common feature is ore and slag in the fireplaces. This is often tapping slag rather than forging slag. Both the slag and the stones may have served as warming devices.

In seven cases, one or two fireplaces lay within a culture layer. The culture layers are primarily composed in the same way as the hearths, although with less charcoal and fire-cracked stone. They vary from thin up to a thickness of 15 cm. The layers appear rectangular or square with an area of 10 to 34 m², including four in the range of 12–15 m². These layers are interpreted as floor layers in huts or similar light structures. There are few structural elements. At case study Jfp.20, corner post pads were found, but nothing certain can be said about the type of building.

More information came from the excavation of Jfp.28. Here, a rectangular building was found which had partly been sunk into the top of a bank. The ruin had two low banks meeting at a right angle on the crown. The size of the building, including the banks, was 3.9 × 3.5 m (Fig. 3.30, see Fig. 3.33 for interpretation). A culture layer which lay between the banks consisted of a layer of clay at

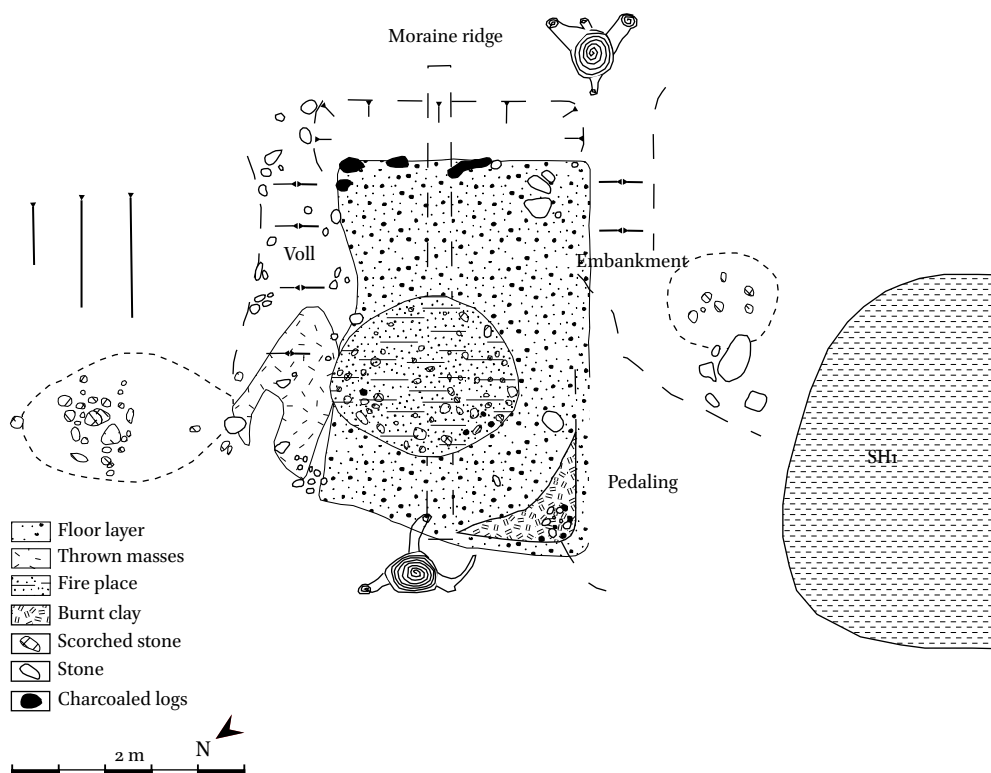


FIGURE 3.30 Plan of building at Jfp.28. See Figure 3.33 for a suggested reconstruction
BY U. GRØTBERG/B. RUNDBERGET, MCH

the bottom and an overlying activity layer. The clay layer measured 3.3×2.4 m. It was of varying thickness, up to 12 cm, and levelled the stony ground surface. The activity layer consisted of a dark-brown greasy fill of charcoal and possibly organic material, and it had approximately the same extent as the clay floor. This layer extended out of the building too, to form a tongue towards the production area. This was probably the entrance. The clay layer is interpreted as the floor layer proper while the upper layer was produced by the activity within the hut. The activity layer also included a slate whetstone (C54395/1) (Fig. 3.31) and a fragment of a striking flint (C54395/2).

In the north-western part of the building there was a round fire place of 1.3 m in diameter. This hearth consisted of charcoal dust, a few pieces of charcoal, fire-cracked stone, sand, and burnt bone. From the form, size and position of the hearth within the culture layer, this building is inferred to have been a roof-vented hut with a fireplace. A ground area of around 10 m^2 implies



FIGURE 3.31 *Whetstones found at bloomery sites in the Gråffell area. From left, Jfp.5 (C53377/6), Jfp.14 (C53392/5), Jfp.28 (C54395/1), Jfp.30 (C54390/2) and Jfp.32 (C54349/6)*

PHOTO: M. TEIGEN, MCH

that it was not meant for permanent residence but was rather a cabin for use during smelting.

The hut at Jfp.28 is the smallest one, but the culture layers are otherwise consistent in form and contents. The hearths are found either in the centre or towards one of the short sides. No other wall banks have been found, simply because no other huts were sunk into a ridge of moraine. Artefacts have been found in several of the hearths and culture layers. These are finds that can be associated with repair and other minor work (whetstones, sewing needles, bone combs and fire-flints). Fragments of horseshoes and horseshoe nails have also been found. Burnt bone has been found in every fireplace except one. The zoological identification of the burnt bone shows that it comes primarily from domesticates (pig, cattle and sheep/goat). Beaver, red fox and hare are represented too⁹⁴ but there are no large game animals or birds in the material.

There are also two charcoal pits that were reused for occupation (Jfp.10 and Jfp.14). The pit dwelling at Jfp.10 lay some 5 m north of the site and was recorded during excavation. During deturfing, a low but clear oval bank aligned

94 Bratbak (2001); Hufthammer (2004), (2005), (2006).

north-south and measuring 8.4×6.3 m was found. The bank was disturbed but consisted of gravel, sand and a lot of small stones, together with a quantity of charcoal, and it surrounded a square cut feature with sides 2.8 m long. This pit was shallow, had slightly rounded sides and a flat bottom. The edge of the cut feature was marked with a row of large and medium-sized stones which formed a roughly square frame. The fill of the pit inside the stone setting was made up of four clearly distinct layers, of which the three uppermost were related to the occupation phase and the bottom one to charcoal burning. At the top was a 10–15 cm thick brown-grey layer of quite greasy consistency because of the admixture of charcoal. There was a concentration of fire-cracked stones in this layer. The layer was almost square, with clearly defined corners to the south and east. It extended over the whole of the top of the pit and measured 2.6×2.6 m. The concentration of fire-cracked stone covered an area of 2.1×1.4 m in the western part of the pit. A few pieces of slag were found with these. From its type and consistency and the fire-cracked stone, this layer is interpreted as a floor layer (Fig. 3.32).

Beneath it were two successive fill and levelling layers so that the base of the building was raised in relation to the charcoal pit. At the bottom lay a charcoal-rich layer that represents the remains of charcoal-making. In the immediate vicinity of the charcoal pit and pit dwelling were three mounds or waste heaps of fire-cracked stone.

At bloomery site Jfp.14, both a fireplace plus culture layer and a pit dwelling were found. The pit dwelling was built up in a manner practically identical to Jfp.10.

The construction of the buildings is difficult to determine from the evidence alone. In the pit dwelling at Jfp.10 there are two aspects in particular that have to be considered in this regard: the square stone setting at the edge of the cut feature and the fire-cracked stone in the floor layer. The distribution of the fire-cracked stone implies that the hearth was positioned in the middle of the building, as one would expect in light of the construction and for heat-efficiency. The pit dwelling can be described as a shallow structure with a depth of around 40 cm. The selection of a shallow pit meant that the building had a larger area than it would have had if only the kiln base in question were used. The stone-set kerb may thus have been a revetment to prevent slippage and also a base for benching. The floor area itself was less than eight m², while the total functional area can be measured at around 13 m² with benches 50 cm wide.

The traces of buildings do not point to permanent settlement at the bloomery sites. Their size and form rather suggests that they were temporary dwellings for 2 to 4 individuals. This means that the ironmakers worked in the area

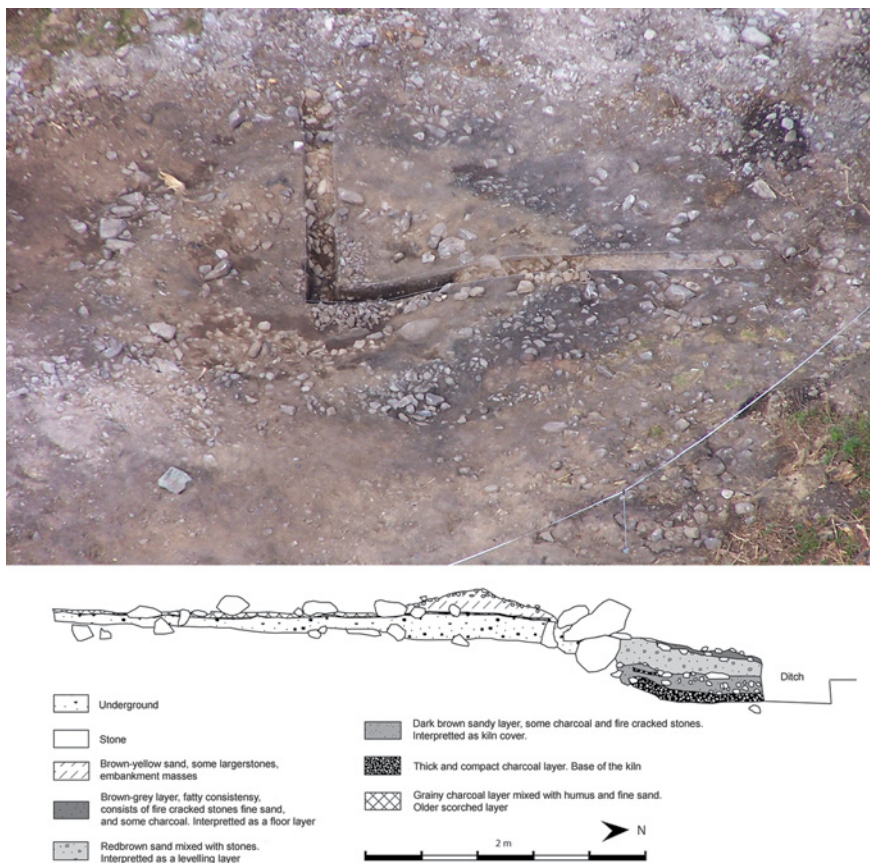


FIGURE 3.32 *Aerial photograph and section drawing of charcoal pit/pit building at Jffp.10. The photograph shows the square stone setting, the cut and the scorched stone clearly. The section drawing shows the structure of the charcoal pit and the building*

PHOTO: K. STEEN, DRAWING BY M.E. EIDE/B. RUNDBERGET, MCH

only periodically, and would otherwise have been resident elsewhere. How that may have worked out in practice will be discussed in due course.

Rødsmoen and the Gråfjell Area Compared

As emerges from the methods of production previously described, the organization of *jernvinna* at Rødsmoen and in the Gråfjell area respectively shows a number of clear differences. At the same time, though, the same basic principles were present, as represented by the form of the slag heaps and placement of the stockpiles of raw material. In light of their geographical proximity and

the similarity in dates, I assume that the processes were the same in both areas. The variations must therefore rather be seen as expressions of different interpretations, of which the greatest reside in our understanding of the type of furnace and the use of sheds. In the Gråfjell area, the furnace has been identified at all of the sites excavated and, even though they are often only preserved in fragments, the evidence altogether provides a good view of both their construction and position. At Rødsmoen, where six sites with slag tapping furnaces were excavated, only one surviving furnace was found. In statistical terms, the interpretations have to be regarded as less secure. An important point here is that it took nearly a full excavation season before we became able to identify the shaft furnaces in the Gråfjell area. The isolation pits were found, and they were initially interpreted as shaft furnaces with a slag pit on the basis of both the structure and the finds of slag in the walls of the pits. After the well-preserved shaft at Jfp.3 appeared, however, it became easier to find equivalent furnaces. The furnace zones were then cleaned with care, a procedure that was decisive in being able to discover shafts *in situ* and fragmented tapping plates.

Since, in the Gråfjell area, only in two cases have details of structures within the production zones been identified, a permanent over-building was not usual. The ore must have been kept dry, but as there is little evidence of any structure, we can also deduce that leather or bark must have been used as a covering. The need for a bloomery shed is not unconditional, and their absence is corroborated by the fact that immediately outside of the production zones several small buildings intended for occupation while the work was in progress were identified. The traces of these most often appeared in the form of a hearth or a thin culture layer. In one case, at Jfp.28, small wall banks were found and a clearly levelled floor. The limits of the floor and traces of a track to the production area show that the building had four walls and a bench along one short wall. The remains show that it was a durable structure, possibly a cogged building (Fig. 3.33). From an organizational perspective, it is also relatively unlikely that anyone would choose to raise two durable structures, one for living in and one for smelting. In regions where bloomery sheds have definitely been identified they also served as housing.⁹⁵ Just as was recognized during the survey work, the excavation results show that the distinction between 300-type and 695-type sites is of little relevance to the Gråfjell area. The sites that have been examined all bear the marks of a basic plan which is referred to as the 'basic model'. Instead of classifying the sites according to their differences, I have focused upon the similarities in organization. There is variation, but the differences are interpreted in terms of individual choice, topography and the volume of production.

95 Martens (1988); Larsen (1991); Narmo (1996a); Tveiten (2012).



FIGURE 3.33 *Interpretation of ironmaking site Jfp.28 on the basis of the layers and structures excavated. The building is interpreted as a lafted hut from the impressions and the location of the hearth. The workspace and the possible impression of a hole running through the furnace imply the use of a bellows. No post holes for suspending the bellows have been identified, and the suspension frame is therefore inferred to have been movable*

BY R. BORVIK

Charcoal Pits—From Statistical Bulk Sample to Organizational Factor

Introduction

The charcoal pit was the permanent partner of ironmaking after the technology of tapping out of small shaft furnaces came into use in the Late Iron Age. There are many more of these than there are bloomery sites themselves and they are counted as the most frequent type of ancient monument in outlying land. The charcoal pits are crucial objects of research for studies of medieval *jernvinna*, not only in themselves, in terms of morphology and process, but especially in relation to the question of how *jernvinna* was organized within the landscape. In this section it is primarily the former aspects that are discussed, and examples for analytical assessment have been selected with that in view. In Chapter 3 (Charcoal pits), however, I shall bring the charcoal pits into

a more general view from which I undertake an analysis of how *jernvinna* was organized in the Gråfjell area.

In the Gråfjell area, the charcoal pits are a bulk set of finds offering many possibilities for interpretation. Altogether 1,740 charcoal pits have been recorded. The great majority were recorded as square (1,465 cases: 84%) or rectangular (238: 14%).⁹⁶ Altogether, 266 charcoal pits have been investigated.⁹⁷ This is 21% of all the protected charcoal pits (1,280). The charcoal pits were usually excavated as part of the examination of ironmaking sites.

Methodology

The insight that one can gain from the investigation of charcoal pits varies from the level of the individual case to mass data. The information potential is greatest in the latter form. Individual studies provide information on the form, size, construction and phasing of the particular pit. Mass studies bring the individual results into a larger system, and that is crucial to understanding *jernvinna* as a whole.

Methodologically there are several ways in which a charcoal pit can be investigated, and the choice of method varies primarily according to which questions one prioritizes, or according to the time and resources available. Test pits and sectioning by machine were the usual procedure. In both cases, the pits were drawn in plan. When digging test pits, the principal object was to find dating material, although it was also in some cases possible to reveal details of construction. With machine-sectioning, half of the charcoal pit was removed to produce one complete cross-section. The section was always aligned with the bloomery site the pit was believed to relate to, to shed light on their relationship and the issue of the removal of fill: the extraction and transport of material can be observed in layers of charcoal overlying the banks. The machine dug mechanical spits in order to reveal details at various levels. The base of the pit was excavated and cleaned. At this level, the form of the pit was clearly visible and constructional details could be seen in the layer of charcoal.

A third method used was the removal of spits by machine. This method requires a fine, sandy soil and produces poor results if the ground contains a lot of stone so that the differences between layers are blurred. Of the pits examined, 107 were sectioned, test pits were dug in 138, four were dug in spits, and 13 were examined using a combination of sectioning and spits. Four charcoal pits were only recorded at the surface.

96 Risbøl et al. (2002b) 57.

97 Rundberget (2007).

Terminology

The terminology used for charcoal pits is based on Bloch-Nakkerud's work at Hovden,⁹⁸ and was used with certain adjustments at Dokkfløy and Rødsmoen.⁹⁹ Bloch-Nakkerud chose to describe the charcoal pit using three measurements: *Outer diameter*, the horizontal distance between what appeared to be the outermost edges of the bank; *internal diameter*, the horizontal distance between the highest points of the bank on either side; and *depth*, the vertical distance between the line representing the internal diameter and the base of the charcoal pit. This choice of measurements has its origin in the understanding that the kiln had been equally large above ground level as below it, and that the fill of the banks must have been placed around the pit deliberately, in order to create a pit of greater depth than the cut feature itself.¹⁰⁰

In more recent studies, the same terminology has been used in order to maintain comparability, amongst other reasons. The internal diameter and depth are the most relevant details as these provide information on the volume of the pit and thus provide a basis for calculating charcoal production. Bloch-Nakkerud's terminology was, however, developed for round pits with clearly capped banks, and can be problematic when the charcoal pits have different forms and where the terrain is sloping. Amongst other things, the charcoal pits in Hedmark are nearly all four-sided, and they often have quite flat banks. In the context of a minor excavation of charcoal pits in the Gråfjell area in 2001, the measurement point for the internal diameter was debated, and the cut edge in the original ground surface was used to determine the internal diameter because this was considered to be a more reliable reference point as long as there was only moderate erosion of the edges.¹⁰¹ On this basis, the investigations consistently took measurements both from the edge of the cut (internal measurement) and a point defined as the bank top (the tangent) in order to be able to analyse these charcoal pits as comparative data along with other studies of such pits.

During the investigations, the distinction between rectangular and square charcoal pits was defined as being that the length is at least 1.3 times the width. This ratio is defined on the basis of a 2×1.5 m 'rectangle'. The 'square' is thus not a perfect square, which of course we would very rarely find because of later disturbances such as slippage. All ratios lower than the given figure are counted as square and higher ones are rectangular.

98 Bloch-Nakkerud (1987) 21.

99 Larsen (1991); Narmo (1996a), (1997).

100 Bloch-Nakkerud (1987) 87.

101 Bøckman and Bergstøl (2001) 4.

The Archaeological Investigations

As in the case of the bloomery sites, it is not possible to present the excavation results in their entirety, and those who are particularly interested in these are directed to the excavation report for the details.¹⁰² I shall present examples of the main elements, such as form and structure, reuse and process, here.

Test Pits

Of 134 charcoal pits examined by surface recording and test pits, 10 had been recorded as rectangular but were redefined as square. Only one charcoal pit that was recorded as square went the other way to be redefined as rectangular. These interpretations are based on several factors, of which the form of the base, the relationship between the form of the base and the internal measurement, and erosion of the sides, are the most important. In the case of the charcoal pits that were defined as rectangular, it is clear that the difference between these and the square pits is that the proportions between the internal measurement and the base of the pit are more or less constant while the degree of erosion is largely the same on every side. This is also the case when one looks at the size of the base in relation to the internal measurement.

The test pits were dug towards the sides of the charcoal pits where the charcoal layers are thickest and it is usually possible to determine details of construction. A problem in the use of test pitting for the interpretation of phases is that the section produced provides limited information. Several layers of charcoal may be formed at the sides of the pit without necessarily being the product of multiple phases of use (see below). Only clearly differentiated charcoal layers are secure evidence of several phases of use. Only two charcoal pits have been classified as having more than one definite phase of use, but the figure should probably be higher. In some cases, constructional elements could be recorded too. Preserved logs lying in layers were considered sufficient to determine the direction of packing. This was visible in nine cases. In five pits, the logs had been laid crosswise, and they were laid parallel in four pits.

Excavation by Machine

Of the 107 pits investigated which were sectioned (Tab. 3.5), 86 had been recorded as square, 13 as rectangular, and two as unclassified, while three were hunting traps reused as charcoal pits. Three charcoal pits were recorded through excavation and so have no record here. Through excavation it transpired that only six of the charcoal pits were rectangular, of which only two had

102 Rundberget (2007) 247–278.

TABLE 3.5 *Charcoal pits investigated in the Gråffell area according to method*

Excavated pits	Number	Examination methods—percentage in parentheses				
		<i>Cross-section</i>	<i>Test pits</i>	<i>Spits</i>	<i>Sectioning/spits</i>	<i>Surface recording</i>
2003	51	28 (54,9 %)	23 (45,1 %)	—	—	—
2004	122	50 (41 %)	59 (48,4 %)	1 (0,8 %)	8 (6,6 %)	4 (3,3 %)
2005	85	29 (34,1 %)	48 (56,5 %)	3 (3,5 %)	5 (5,9 %)	—
2003–05	258	107 (41,5 %)	130 (50,4 %)	4 (1,6 %)	13 (5 %)	4 (1,6 %)



FIGURE 3.34 *Section through charcoal pits Jfp.10–3 and Jfp.10–4. In the section, typical stratigraphic sequences can be made out quite easily*
PHOTO: K. STEEN, MCH

been recorded as such. In other words, 11 charcoal pits that had been recorded as rectangular were in fact square.

Interpretation of Sections and Phases

The sections of the podzol in the natural soil make it fairly easy to distinguish layers in charcoal pits (Fig. 3.34). The interpretative problems relate primarily to the sides of the pits because of the actions of the charcoal-makers and later slippage. Typical layers in the section of a charcoal pit are, from top to bottom: turf/humus; bank fill/kiln cover; bank fill/upcast from the digging of the pit;

the old ground surface; a white washing-out layer above a red-orange enrichment layer that gradually transforms into a grey soil. In the pit itself there is also the base of the kiln and a thin layer of burnt sand/gravel. In those cases where the pits are used more than once, several bases can be seen (Fig. 3.35).

Traditionally, the phases of use have been interpreted in three lights: complete layers at the base of the pit; stratigraphy in the bank; and the evidence of several layers of charcoal at the sides of the pit. The layers running through the base of the pit and the bank can be treated as secure evidence, but it is more problematic to define multiple phases from layers of charcoal on the sides. The stratified charcoal layers at the edges of the pits at Rødsmoen were interpreted as evidence of multiple phases of use. This was because it was assumed that remains of the previous layer of charcoal had still been lying there when the pit was shovelled out and cleared for a fresh round of production. During these actions, sand also slipped over the layers of charcoal and the earlier phases were thus sealed.¹⁰³ In the Gråfjell area, two charcoal pits that had not been emptied after burning were examined. Together with charcoal pits that were repacked immediately after emptying, these gave a good view of what the pits look like right after emptying. In both cases, clear tongues of charcoal were found which



FIGURE 3.35 *Section of charcoal pit Jfp.29-7 showing two activity phases*
PHOTO: O. TVEITEN, MCH

103 Narmo (1997) 77.

could not be associated with reuse of the pit. It is clear that, during the work, fill from the sides slipped in and down between the logs that were lying parallel with the sides. This phenomenon inevitably means that the pits were not emptied right up to the sides, where a large amount of soil was mixed in with the charcoal. Over the following centuries, steady slippage has pressed the charred logs together so that they now appear as pointed *tongues* when excavated. An example of this is charcoal pit Jfp.1–2 (Fig. 3.36), where the charcoal tongues in the side of the pit were first interpreted as representing several phases of use.

Of the charcoal pits with layers running across the base of the kiln and the bank, 19 of the 122 dug by machine were recorded as having two or more phases of use (Fig. 3.35/Fig. 3.37). This is 15.6%. Nine of these could be defined from the base of the kiln, four from the bank and six from a combination of these. It is overwhelmingly probable that more charcoal pits had several phases of use but it has not been possible to demonstrate this. I therefore suggest that reuse was at a level of at least 20%, and probably more.

The Base of the Pit

‘The base of the pit’ is the description of the charcoal that is left lying on the base of the charcoal pit after it has been emptied, and it is here in particular that many key details of interpretation, such as form, details of construction and material for dating, are provided. In several cases, large quantities of charcoal were left. This may be explained by several factors, such as pollution, poor carbonization, or the storage of charcoal in the pits which was not all removed. An example of storage is charcoal pit Jfp.9–12, where the base of the pit

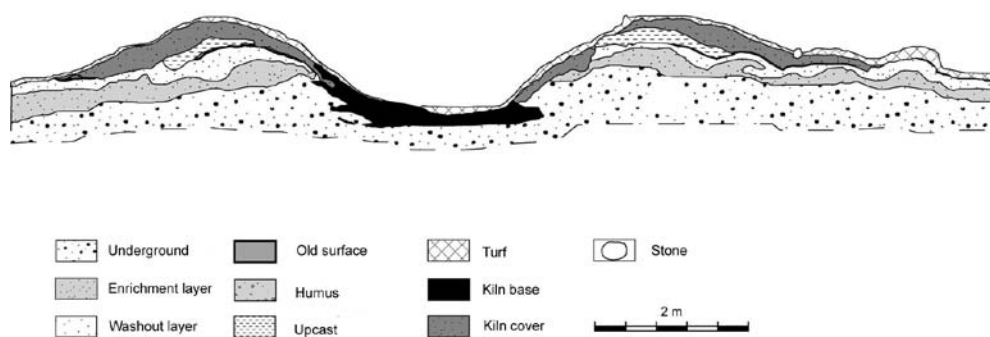


FIGURE 3.36 *Section drawing of Jfp.1–2. In the wall of the pit to the left were found four layers of charcoal which had previously been seen as associated with different phases of use. The study in the Gråfjell area showed, however, that these layers were formed during construction and process*

BY R. BJØRNSTAD/B. RUNDBERGET, MCH

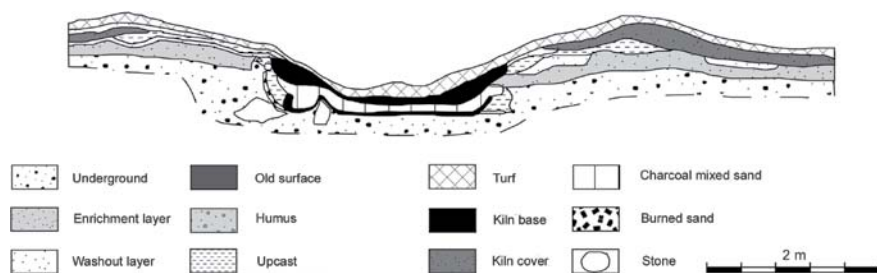


FIGURE 3.37 *Charcoal pit Jfp.29-7 with two clearly separate phases of use. The base of the kiln of the second phase is slightly off-line in relation to the original one*

BY H. DAMLIEN/B. RUNDBERGET, MCH

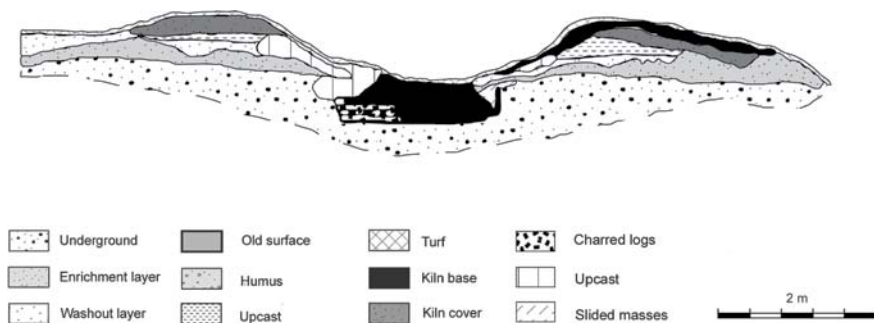


FIGURE 3.38 *At one side of charcoal pit Jfp.9-12, several preserved layers of logs were found. All the charcoal was probably not taken out at the same time, and it is possible that the charcoal left was stored and intended for later combustion*

BY U. GRØTBERG/B. RUNDBERGET, MCH

was 65 cm thick. Towards three of the sides lay whole or partly incomplete logs of wood in a crossing pattern. Above the logs lay a thick layer of mixed sand and charcoal which was probably the remains of a cover. Later ground movement has pushed the layer inwards, and the eroded material has subsequently been laid over the wood (Fig. 3.38). The majority of the charcoal was taken out, but some of the fill was deliberately redeposited, probably to be collected later. The storage of charcoal in pits is described from the Early Modern Period.¹⁰⁴ It can be stored in covered pits very well for up to two years before it is damaged by moisture.¹⁰⁵ In England, stored charcoal is described as lasting more

¹⁰⁴ Bloch-Nakkerud (1987).

¹⁰⁵ Narmo (1997) 77.

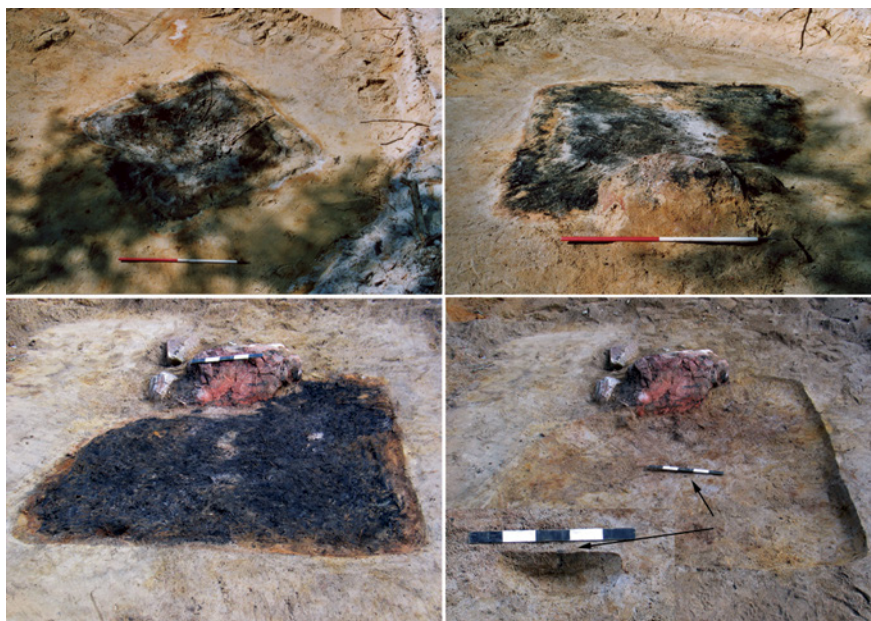


FIGURE 3.39 *Charcoal pit Jfp.30-2. The base of the kiln. Bottom right, the photos show a black spot (arrow) in front of the survey pole which represents an impression left by a small firing post that was placed in the middle of the pit*
 PHOTO: B. RUNDBERGET, MCH

than five years.¹⁰⁶ The stockpiling can be associated with the cycle of the various tasks that were part of *jernvinna*, and long-term storage in open stockpiles at the bloomery site does not make sense.¹⁰⁷ Charcoal-burning was probably done in the autumn or winter, and the ready raw material must then have remained waiting for iron production to start later in the year.

The base of the pit was in several cases found as a framework of logs, which was often square. The framework of wood was preserved when it was covered by eroded fill. A square base was also discovered in charcoal pits excavated in spits. Using this method, other constructional details were revealed too. An example is Jfp.30-2 (Fig. 3.39). During deturfing, thin, charcoal-mixed layers were found in the bank, which is the remains of a kiln cover. A layer of nearly pure charcoal lay above this and outside of the bank to the west. This layer shows in which direction the charcoal was removed from the kiln. Lying on the southern side was a large, earth-fast stone, which was clearly affected by the

¹⁰⁶ Kelley (1986).

¹⁰⁷ Narmo (1997) 77-78.

heat. The stone interfered with the pit, and the logs were shaped around it. The base of the kiln thus had three corners. It measured 2×2 m, determined by an incompletely preserved wooden frame. The lower part of the base of the pit consisted of fragmentary logs which lay densely packed within the framework, all of them aligned east-west. Below the logs, in the centre, the impression of a piece of charcoal was found in the natural soil. This was the remains of a 3–4 cm-thick pointed stick that had been driven 10 cm into the ground.

Unemptied Charcoal Pits

On some occasions, unemptied or only partially emptied charcoal pits are discovered.¹⁰⁸ Three such pits were found in the Gråfjell area, and two of these were excavated. The excavation of these produced a series of new results which had previously been unknown.¹⁰⁹

Charcoal pits may not have been emptied in order to store the charcoal. Charcoal pit Jfp.11–6 seemed to be entirely untouched after the burning and appeared quite forgotten. This is not something that just happens in the context of reduced work. The reason why it was abandoned can be seen in connection with bloomery site Jfp.11, the organization of which indicates that it was prepared for long-term and intensive work. Activity there was, however, ended after a short time, which may explain why the charcoal pit was not emptied. In the case of charcoal pit Jfp.29–3, there is another explanation besides storage, as several of the logs had not carbonized throughout. The cover of the kiln had been removed in one corner and some of the uppermost pieces of wood had been taken out. But as they were not charred well enough it is not unlikely that the kiln was abandoned.

A number of details of construction and process were revealed by the excavations. The building-up of the pits was the same. Both charcoal pits were constructed with an internal box of wooden logs which rested on two sill beams (see Fig. 3.40). The length of the wood in the box was 2 m in both pits. The pits had angled sides and the measurements at ground level were 3 and 3.3 m. In charcoal pit Jfp.11–6 there were seven layers of logs while charcoal pit Jfp.29–3 had nine (Fig. 3.41). In the space between the box and the wall there was a framework of wood. In the corners were cut logs running diagonally down to the base of the pit. In the centre of charcoal pit Jfp.11–6 there was also a stake that had been driven vertically into the ground (Fig. 3.42). Firing is also deduced to have taken place by means of a firing shaft through the middle of the kiln, while the firing of all types of kiln has to take place as deeply as possible

108 Bloch-Nakkerud (1987); Narmo (1997).

109 Damlien and Rundberget (2007).



FIGURE 3.40 *The two emptied charcoal pits Jfp.11–6 and Jfp.29–3. Above, charcoal pit Jfp.11–6. Below, charcoal pit Jfp.29–3*

PHOTOS: I. GUNDERSEN/H. DAMLIEN/B. RUNDBERGET, MCH

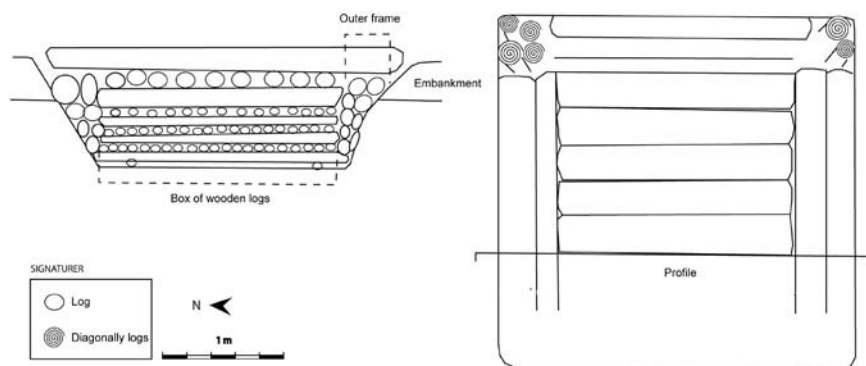


FIGURE 3.41 *Plan and section of charcoal pit Jfp.29–3 with the number of widths and heights of logs*

BY H. DAMLIEN/B. RUNDBERGET, MCH

for the logs on the bottom to catch fire. A shaft was constructed in the middle of the charcoal pit and a burning stake was driven down to set light to the tinder and kindling which was placed at the base of the pit.¹¹⁰

The similarities between these pits are many, but there are some differences. The wood in Jfp.11–6 was packed parallel while that in Jfp.29–3 had been laid

¹¹⁰ Bloch-Nakkerud (1987) 71, 93–94.

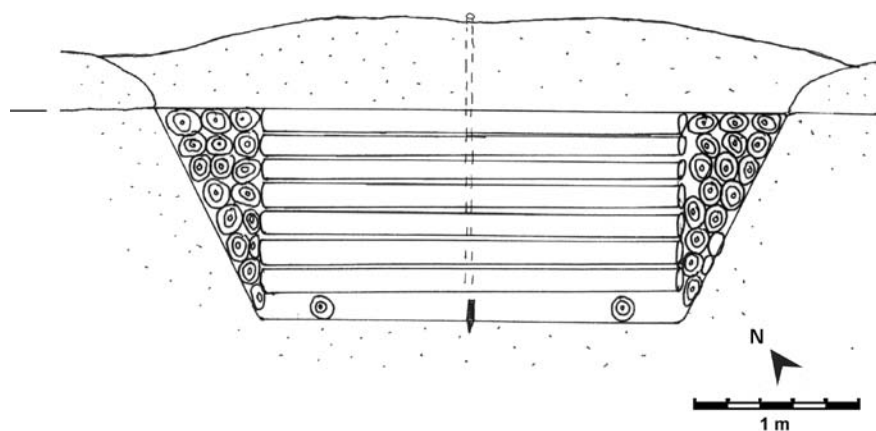


FIGURE 3.42 *Interpretation of the timber construction based on the charcoal pit Jfp.11-6*
DRAWING: B. RUNDBERGET, MCH

crossways. Another feature is that no firing stake was seen in Jfp.29-3. A more important difference in relation of the calculation of volume is that the timber in Jfp.29-3 was packed up to the bank top (see Fig 3.41) while that in Jfp.11-6 was up to the ground level. A relevant point may be that Jfp.11-6 was 1 m deep while Jfp.29-3 was only 0.6 m deep. To this can be added a bank of 0.3 m, and the total depth is about the same.

One feature is that the logs were deliberately packed so that those with the smallest diameter were at the bottom and the thickness gradually increased towards the top. This is probably connected to the fact that the logs towards the bottom of the kiln receive less of a draught than those towards the top. By placing the logs in this order, a more even process of carbonization was achieved.

The construction with leaning logs in the corners has to be viewed in terms of controlling the air supply. In the later charcoal kiln tradition, it was usual to create vents in order to introduce and regulate the air pressure.¹¹¹ In the Gråfjell area, the vents were placed in the corners where the draught was drawn down along the angled logs and then spread around within the kiln at the same time as the smoke escaped. The crossing logs in the base of the kiln which held the structure up off the ground created a direction of flow and the air spread below the kiln. As well as creating pressure below, this raising also served to protect the logs from damp from the ground. The features observed in the unemptied pits have also been noted in other charcoal pits. This is the case, for instance,

¹¹¹ Larsen (1996) 77, 89.

with charcoal pits Jfp.9–12, Jfp.14–13 and Jfp.30–1, where the impressions of sloping logs were seen in the corners of the cut of the pit.

The thickness of the cover corresponds to what is described in the later kiln tradition. In order to cover the wood, the pit was covered over, first simply with heather or moss. The cover needed to be 15 cm thick so that the soil above it would not slip into the kiln. Then earth and sand were laid over the pit to a thickness of 15 cm at the sides and 25 cm at the top.¹¹² The thickness and composition of the material mean that one can assume the same methods to have been used in the pre-modern period too.¹¹³

Concluding Remarks

The investigations of charcoal pits in the Gråfjell area revealed a discrepancy between the results of recording and of excavation. One aspect is the identification of rectangular charcoal pits. In all, 38 charcoal pits that had been recorded as rectangular were examined. 21 of these (55%) were reclassified, and only 17 (45%) retained that identification. In other words, of the 266 charcoal pits investigated, only 6% were rectangular. This variation is interpreted as being connected to the technique of stabilization.¹¹⁴ An interesting aspect is the relationship with Rødsmoen, where 24% of the charcoal pits were rectangular. The area by Flåtåstøa, to the south-west of the Gråfjell area, which also has a high number of rectangular pits, is also that closest to Rødsmoen. Three of the four charcoal pits examined at Jfp.30 were clearly rectangular. Two pits at Jfp.30, Jfp.30–1 and Jfp.30–2, of which the former was rectangular, were excavated in spits. The examination of these pits nonetheless revealed a similar formation with parallel packing, corner posts like those found in the unemptied charcoal pits, and bearing logs or sill beams to hold the structure up off the earth. The similarities are thus multiple. That rectangular and square pits in the Gråfjell area represent different charcoal-making methods is thus quite unlikely. The rectangular pits should rather be regarded as a variation on the normal method of charcoal burning, reflecting factors such as the need for charcoal or the stoniness of the ground. Except in the south-west, the rectangular pits are scattered across the area in no clear pattern, and it is scarcely credible that special groups or agents were responsible for them. When it comes to the size of the charcoal pits, there is equally no relationship with location. Both large and small pits are found across the whole area of study. The variation in size shows that a large volume could be burned when needed. As in the case of

¹¹² Larsen (1996) 88.

¹¹³ Narmo (1997) 77.

¹¹⁴ Narmo (1997) 105–106.

the bloomeries, I believe therefore that *similarity* is a key feature. The evidence clearly shows that there was a uniform charcoal-making tradition with definite connections to the practice of ironmaking. The relationship between charcoal pits and iron extraction will be discussed further below. Before then, however, it is necessary to present the results from the investigations of roasting places in the Gråfjell area as these are also a central component in how the organization of *jernvinna* is to be understood.

Roasting Places—A Factor in a Comprehensive Understanding

It has been difficult to demonstrate where ore has been gathered from the bog and roasted, as these ancient monuments are rarely visible. The roasting of ore was to some extent undertaken at the bloomery sites, and our knowledge of its preparation is largely derived from these.¹¹⁵ During the survey work in the Gråfjell area, nine roasting places were identified a fair distance from the nearest ironmaking site.¹¹⁶ Their placement was associated with areas of high potential for the precipitation of bog ore. Two roasting places were revealed by the preparation of a plot for reforestation. Six were found using a magnetometer, while in one case there is no information on how it was discovered

Terminology

A problem affecting roasting places has been the creation of systems of classification. This particularly involves the ability to distinguish roasting places from stockpiles of ore and accumulated ore grains. During the Dokka Project, Narmo proposed five criteria for what might define a roasting place:¹¹⁷

- Bounded rectangular or square concentrations of roasted ore (2–6.5 m).
- Ground affected by heat. This is not always present, as the roasting is carried out above the ground level, but it is a definite criterion when it can be identified.
- A layer of charcoal below a layer of ore. This is an uncertain criterion as the charcoal was mixed with the ore in the roasting process. It can reliably be used when the ore is mixed with more charcoal towards the middle.
- The layer of ore is thicker in the middle than out to the sides. This is indeterminate on its own but a useful indicator.

¹¹⁵ Larsen (1991); Narmo (1996a), (1997).

¹¹⁶ Risbøl et al. (2001) 59, (2002a) 54, (2002b) 55–57.

¹¹⁷ Narmo (1996a) 59–60.

- A combination of roasted and unroasted ore. The unroasted ore will be found around the roasted ore.

During the Rødsmoen Project, two further factors which may indicate roasting were emphasized: the location of the roasting places at the production sites¹¹⁸ and the levelling of the ground for roasting.¹¹⁹ The terminology is based on concentrations of ore at bloomery sites but can also be applied to separate roasting places.

For the roasting places, a number of fixed terms are used for various elements. For the Gråfjell Project, the following have been used;

- Roasting fire: Refers to the activity of roasting and its remains.
- Roasting place: The site at which roasting was carried out. This may consist of one or more roasting fires, either in a stratified sequence or in close proximity to one another, within a small, defined area.
- Separate roasting place: Roasting places or fires which are not at or immediately beside a bloomery site.
- Raw ore stockpile: A stockpile of raw ore at the place it was extracted.

Methodology

The investigations of roasting places in the Gråfjell area took two forms. Recording was undertaken with the aid of the magnetometer and then excavation was undertaken of a sample of the sites recorded. Roasting places were also investigated at several of the ironmaking sites.

Recording with a Magnetometer

Geophysical methods for investigating features in the upper soil are primarily used for the study of geological structures. In archaeology, these methods have been valuable as they can often reveal human activity. The magnetometer is used to measure anomalies in the magnetic field of the ground. In the Gråfjell area, the geological conditions are good as the ground consists of sedimentary rocks of low if any magnetism. The conditions that the magnetometer most often reveals are the presence of magnetic magnetite in the bedrock and in minerals. This means that the method is especially helpful in mapping iron-making activities. Both through roasting and the process of reduction, strongly

¹¹⁸ Narmo (1997) 27.

¹¹⁹ Narmo (1997) 64.

magnetic minerals are produced, whose distribution and delimitation can be followed in detail.¹²⁰

Magnetometric survey was first tested in NIKU's survey work. It was bloomery ironmaking that was principally mapped.¹²¹ The method itself was two-fold, consisting of *free searching* and *detailed plan-making* (Fig. 3.43).¹²² Through free searching, areas with anomalies were identified and delimited by ranging across the terrain. The level of precision of identification is 0.5–1.5 m. Then a small intervention with knife or trowel and magnet was undertaken to confirm whether the anomalies came from roasted ore. By free searching, one can map 3 or 4 hectares (ha) per day. Detailed plan-making involves mapping within a smaller area. A grid system of strings at 0.5 m intervals is laid out. The magnetometer is set to take a measurement every 0.2 seconds and the area is mapped by moving along the string lines, thus taking a reading every 0.2–0.3 m. The mapping is digitally processed and a schematic plan is produced in which the strength of the anomalies, the maximum and minimum values, and their distribution are all made visible (Fig. 3.12).



FIGURE 3.43 *Tatyana Smekalova making a detailed plan of roasting site Rp.24. The yellow flags mark anomalies identified by free-searching. Blue-coloured pins mark the centre of the roasting site*

PHOTO: S. SMEKALOV, MCH

¹²⁰ Smekalovs (2006).

¹²¹ Risbøl et al. (2001), (2002a), (2002b); Smekalovs (2002).

¹²² Smekalovs (2006).

The Archaeological Examinations

Most of the roasting places were examined by sectioning. The turf was removed by machine and the area was cleaned in plan in order to record the extent and number of roasting fires. A section was cut and half of the roasting fire dug away. The section, the ground and any constructional details were recorded using the terminology adopted.

Magnetometric Surveys

The magnetometric surveys were undertaken by the geophysicists Tatyana Smekalova and Sergej Smekalov.¹²³ In the excavations, the method was developed further in order to identify the location of roasting places. Initially, a search was undertaken around several sites near Tørråskjølen, an area which contains seven bloomery sites with associated charcoal pits.¹²⁴ All of the sites were excavated or recorded on the surface and mapped using magnetometry. The search was done by circling around the terrain. The result was striking, as 54 roasting places were recorded within a small area (Fig. 3.44) while no other roasting places were found in the vicinity. In addition, three new bloomery sites were found (Jfp.3, production site 2, Jfp.18 and Jfp.35). These were not immediately visible from the surface but were small rises in an undulating and clumpy terrain. The position of the recorded roasting places was linked to ore-rich areas and not with any particular bloomery site. On the strength of this discovery, in the following excavation season four new areas were searched which from their topography and geology had good conditions for outcrops of ore. Fully 179 roasting places were identified here¹²⁵ (Fig. 3.45).

Aspects of Location

A common feature of roasting places is that they are located in sheltered bogs, often between two large flat raised bogs. An example is the 500-m belt between Eldmyrene and Malmmyra (Fig. 3.46), which has a difference in altitude of some 70 m. The landscape comprises ridges and drier flat areas surround by large wet areas with much trickling water. The morainic ridges have vegetation consisting of bilberry heather and moss while the wet areas are overgrown with bog grass. The higher vegetation consists for the most part of spruce, varying from sparse to dense. The ground is stony and the bedrock protrudes in knolls. Precipitation of ore is visible in several places, especially in association with streams and bedrock. The recorded roasting places all lie on the drier higher

¹²³ Smekalovs (2006).

¹²⁴ Rundberget (2006) 15–32.

¹²⁵ Smekalovs (2006).

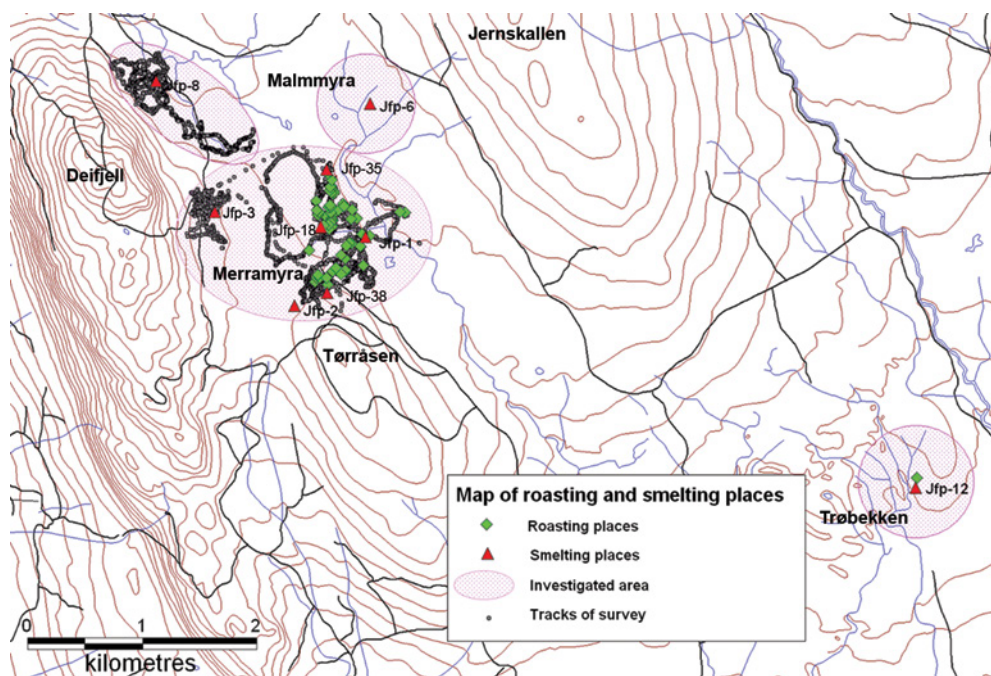


FIGURE 3.44 *Mapping by magnetometry. The recorded roasting sites lie close together in slightly sloping terrain between Merramyra/Tørråskjølen and Malmmyra. No roasting sites were identified around bloomery sites Jfp.2, Jfp.3, Jfp.5 or Jfp.8, after Smekalovs, MCH*

areas and knolls (Fig. 3.47). Large quantities of fresh ore were found over the whole area, both as fine deposits in rivers and as thick layers of granular ore or pieces weighing up to a kilogram directly beneath the turf.

Of the total of 242 recorded roasting places, 28 were investigated by fieldwork. The excavations revealed roasting places with one or with several roasting fires. The investigations are described in the excavation report;¹²⁶ two examples are selected here, one roasting place and one roasting area with several roasting places.

Roasting Place Rp.16

Rp.16 is one of seven roasting places which lay in a row on a north-south ridge on the slope from Tørråskjølen down to Malmmyra. Four of these sites (Rp.14–Rp.17), which comprised two to five fireplaces, were excavated. Rp.16 had two roasting fires within an area of 6×4 m. Roasting fire 1 consisted of a roughly

¹²⁶ Rundberget (2007) 279–308.

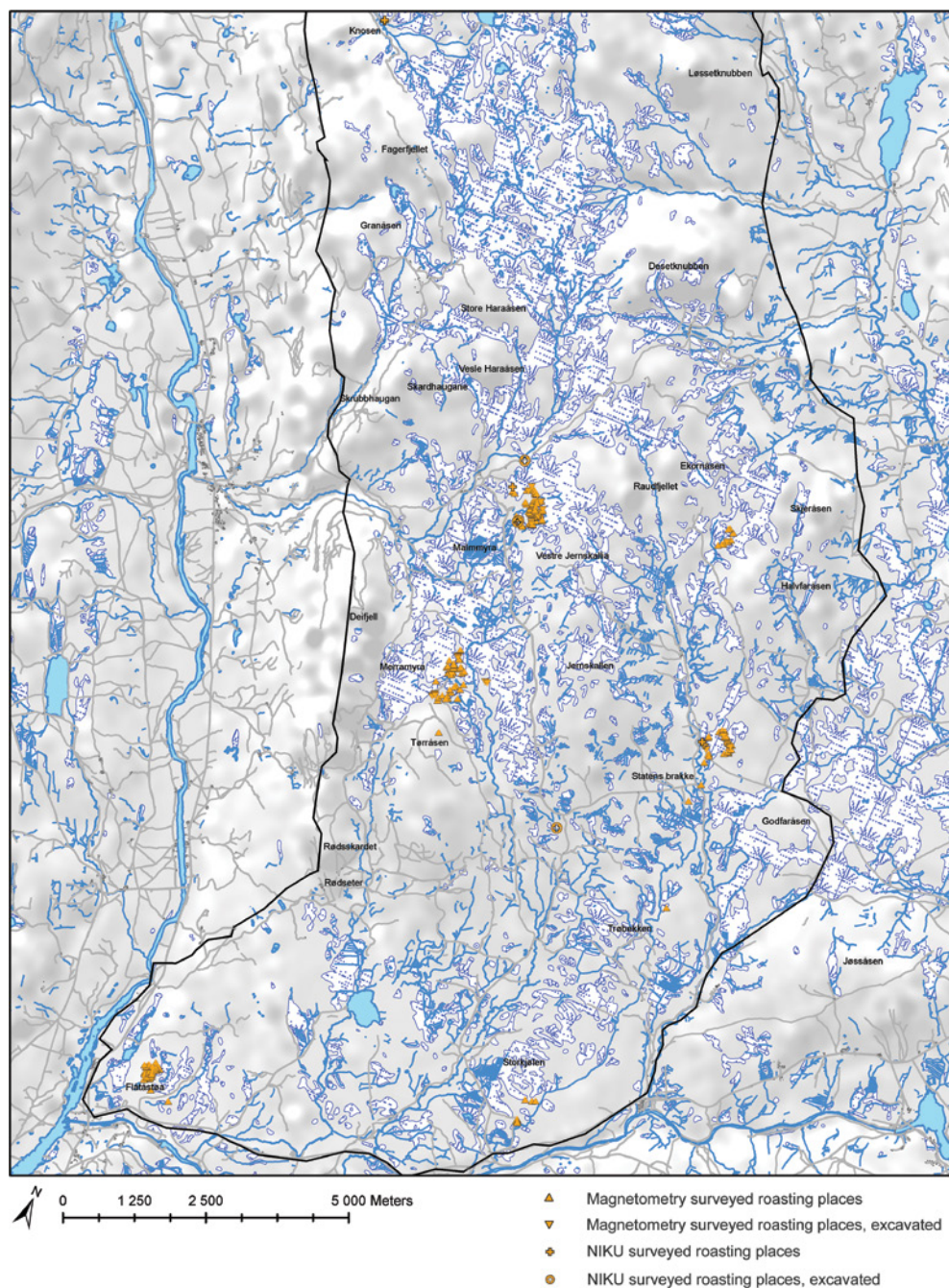


FIGURE 3.45 *Roasting sites recorded in the Gråfjell area. The roasting sites lie close to hillslope bogs in gently sloping terrain*

MAP: D. HILL, MCH

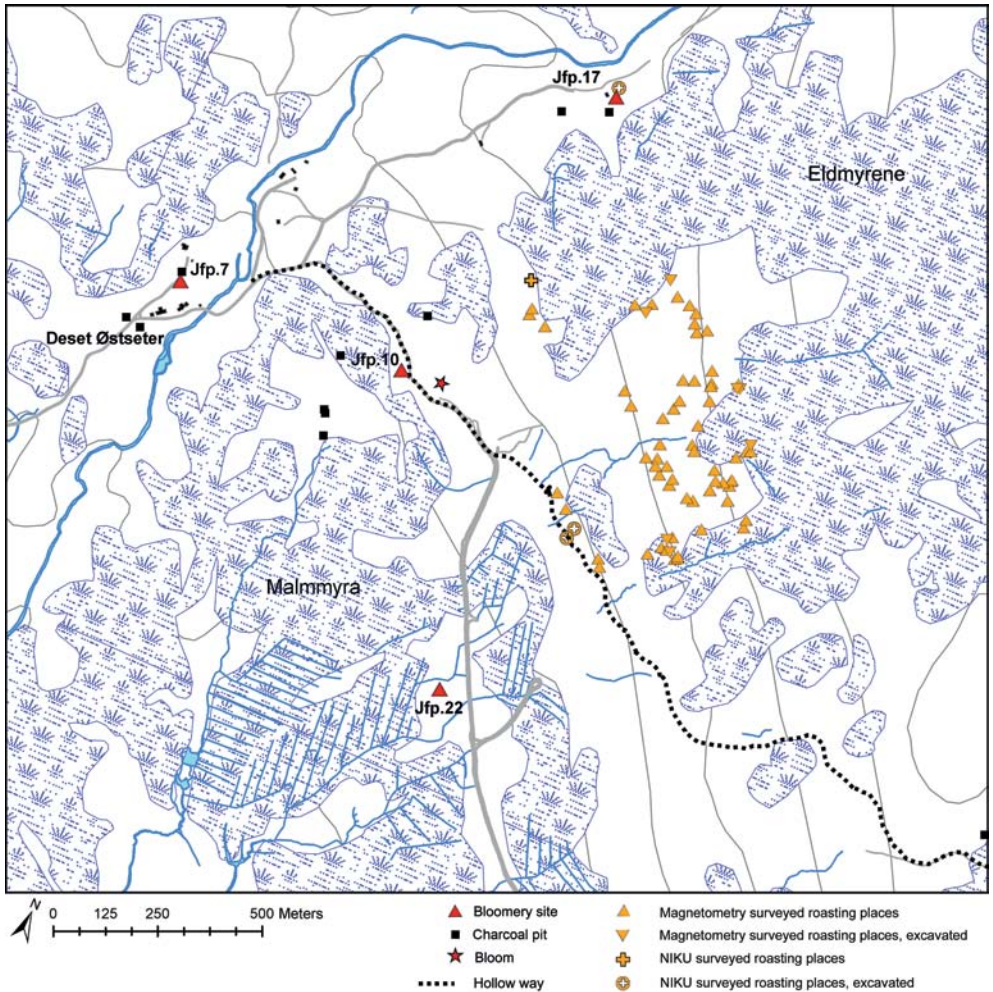


FIGURE 3.46 *Roasting sites in Vestre Jernskallia between Malmmyra and Eldmyrene. The place-names imply activity associated with iron extraction (see Ch.3, Jernvinna in the Gråfjell area—organization and exploitation of resources). Note that there has been no charcoal-making in the area where roasting was undertaken*
 MAP: D. HILL, MCH

square layer of ore with clear edges except in the south where it was rather blurred (Fig. 3.48). The ore was of the powder ore type with pockets of lumps and grains. To the north, several stones lay in a row beneath the ore layer as an edge to the roasting fire.

Roasting fire 2 was roughly square to judge by its clear edges, fire-cracked stone and heat-affected ground. It was rather blurred to the north but several placed stones delimit the roasting fire. The thickness was variable because the



FIGURE 3.47 *Roasting site Rp.22 identified on a spruce-covered 'island' in a grass-covered hillslope bog between Eldmyrene and Malmmyra*
 PHOTO: B. RUNDBERGET, MCH



FIGURE 3.48 *Rp.16, fireplace 2 after cleaning. The roasting site was nearly square*
 PHOTO: B. RUNDBERGET, MCH

ground beneath was very stony. Fragments of charcoal from the base of layer of ore are dated to AD 630–780 (T-18016, 1350 ± 95 BP), somewhat earlier than the major bloomery activity. There is a comparable date from Rp.17 (T-18017, 1340 ± 60 BP, cal AD 650–770) while Rp.15 is dated to AD 1030–1265 (T-18015,

885±95 BP). The dates are exciting as the earlier ones are contemporary with Jfp.18 which is only 200 m away.

Roasting Place Rp.18

This roasting place lay on an east-west ridge with sheltered bogs on both sides. It appeared as a truncated pyramid with a square base and an outer measurement of 1.8 m (Fig. 3.49). The flat top measured 1.2 m and it was around 0.3 m thick. The roasting place had probably been emptied. The ore had a red shade on the surface, but around the mound there was a thinner layer consisting of red to brown ore with various sizes of grain and degrees of roasting. After sectioning, the layer of ore could be seen to have three parts. Below it lay a belt of intense, light-red powder ore, which in turn lay immediately above a thin, general layer of charcoal. The thin bottom layer consisted of a thick, composite, dark-brown layer of coarse-grained roasted ore, lenses of charcoal, pockets of fresh ore, and some fire-cracked stones. In the middle of this layer was another compact layer of charcoal. Remains of charred logs also appeared, with a single alignment. Several larger earth-fast stones protruded into the ore layer. All of the ore was weighed, and 59 buckets of 12 litres (708 l in total) produced a weight of 652 kg. Calculation of volume indicates that the roasting fire had a mass of 0.68 m³ or 680 l.

The compact charcoal layers in the base may be remains of roasting (Fig. 3.50). Alternatively, there may have been collapses during the process. The colour shades reflect variation in temperature and the degree of roasting. The intense red ore immediately above the thin layer of charcoal and the burnt logs show where the heat was most intense. At this level there must have been a good draught.



FIGURE 3.49 *Rp.18 before deturfing. The roasting site is in thick spruce woodland, which is typical of areas where the conditions for ore-formation are good. The square shape of the roasting fire is clearly visible*

PHOTO: B. RUNDBERGET, MCH



FIGURE 3.50 *Rp.18 in profile. The photograph to the right was taken using a flash and emphasizes the stratigraphy*

PHOTO: B. RUNDBERGET, MCH

A striking feature is the positioning of the roasting place on and between several earth-fast stones. These served a structural role as one could easily have located the roasting fireplace a little differently in order to avoid them.

There are two dates from the roasting place. Charcoal from the top and bottom of the roasting fire has an effectively identical dating, AD 1490–1655 (T-18174, 310 ± 55 BP) and AD 1520–1655 (T-18175, 300 ± 45 BP). The dates are later than the Hedmark tradition. What these dates represent is uncertain. The Evenstad tradition may have appeared as early as the fifth century but is not particularly well represented in Åmot. In the vicinity of the firing range, only one possible site is known, and that is down in the valley, immediately north of Deset. It is possible that these dates represent a later forest fire, but no clear answer is available. Despite the dating, the method appears to be congruent with what has been recorded at other roasting places, and the volume will therefore be used for reference in Chapter 6.

Interpretation and Discussion

Form and Size

There are very few archaeological investigations which can be tested against the literature on roasting. Martens¹²⁷ treated all of the ore concentrations at Mösstrond as stockpiles. From his work in Jämtland, by contrast, Magnusson¹²⁸ described all concentrations of ore as roasting places. This identification was based upon size, and no other criteria were used. No constructional details are described, but the roasting deposits had a surface area of 20–30 m². Englund¹²⁹

¹²⁷ Martens (1988).

¹²⁸ Magnusson (1986).

¹²⁹ Englund (2002) 185.

writes that the size of roasting places can range from 4–5 m² up towards 50 m². Large roasting spreads are often associated with repeated roasting and the roasting fires were not in fixed sites.

At Dokkfløy, a series of concentrations of ore were identified by the bloomery sites. These did not receive much attention and were only labelled in a few cases.¹³⁰ Narmo used some of this evidence in his dissertation, and studied the concentrations of ore at three sites. The concentrations which he described as roasting places according to his definitive criteria had a surface area of 0.8–3 m².¹³¹ Narmo does not provide information on form, but the dimensions are given as length and breadth, and one can thus infer that they were four-sided. At Rødsmoen, roasting places were identified by bloomery sites, and in the case already mentioned, by a charcoal pit. The roasting places had one or several roasting fires of rectangular or unspecified form and the surface area ranged from 2 to 25 m².¹³²

In the Gråfjell area the form of separate roasting fires is without exception square or rectangular, the majority of the latter form. The roasting fires at the production sites corresponded in form. The size of the roasting fires varied, but the surface area was normally less than 10 m². The same is true of the roasting places at the bloomeries. In both cases it is the rectangular roasting places which may exceed 10 m².

It is difficult to find a uniform pattern in the size of the fires, either in the earlier literature or from the archaeological fieldwork. It is wrong, in my view, to put the extent of roasting in a statistical framework. The roasting fires, with the variation they display, should rather be regarded as a reflex of the quantity of ore collected and the demand for ore when the roasting fire was built, after the ore had been extracted and dried. Although the ore could be stored over winter in relatively dry surroundings, more ore than was needed would not have been roasted. At the bloomery sites there are no stockpiles of ore without associated furnaces. It would appear that the small huts served as store places.

Construction and Process

The only known style of roasting in Norway was described by Evenstad in 1782. A number of authors have also described the process, in more or less the same way, in Norway, Sweden and Finland.¹³³ There are no earlier accounts,

¹³⁰ Larsen (1991).

¹³¹ Narmo (1996a) 64.

¹³² Narmo (1997) 27, 40–41, 64–65.

¹³³ Pettersson (1982) 52–54, with refs.

but I assume that the same method was used in the Middle Ages. The fire was constructed of two to six layers of dry logs, crosswise, resting on two fresh logs at the base. Between the basal logs was placed tinder that would quickly catch light. The dried bog ore was laid on top, in a doughnut shape to create a draught in the middle of the fire (Fig. 2.11). Ideally, the ore would be roasted through when the fire had burnt out. Experiments with the construction and the roasting process have been carried out at various scales and with varying results. One problem has been only the ore on the outside and top becoming oxidized.¹³⁴ Englund has roasted ore on smaller fires. The fire measured around 1 m², and 52.5 kg of ore were roasted through in three and a half hours.¹³⁵

The excavations of roasting places in the Gråfjell area support the accounts of the construction to some extent. The shape was fairly certainly four-sided. In some cases, logs lying horizontally have been found, and in one case the logs lay crosswise. In the great majority of cases, however, the wood has been burnt to ash, and only fragments remain. In some places a rim of charcoal has been found beneath the layer of ore. Looked at in terms of process, with ore constantly slipping down between the logs, a fire that has burnt out will rarely be layered with a coherent rim of charcoal, and if such a feature does appear, a layer of charcoal must have been formed before the ore runs down. This can happen if the logs that are lying right beside the kindling wood are burnt through completely—which should really be the exception rather than the rule. Narmo has pointed out that his experiences with roasting have produced a greater admixture of charcoal towards the centre of the fire. In several cases this has been observed in the ore layers. Even with the limited result that the study of charcoal and charcoal inclusions in the roasting fires has produced, it is reasonable to believe that the construction is similar to that described in the literature.

A recurrent feature is the presence of stones below the roasting fires. At the same time, no signs have been found of clearance or levelling. It is clear, rather, that sites which were dominated by earth-fast stones were used. Stones were also deliberately brought in. There is no overall pattern, but there are indications that the stones are more numerous out towards the sides of the roasting fire. These stones could have had several functions. They can be associated with collapse, with the objective being to avoid the ore spreading outwards. Stones lying within a fire that collapses will also be able to provide a draught into the fire, which would be important with large fires and a large load of ore. The positioning of the roasting fires on slightly sloping ground may similarly be linked

134 Narmo (1996a).

135 Englund (2002) 211–213.

to the use of stones in the construction, to provide an even foundation for the basal logs. There is a tendency for the stones to be sited at the lowest point of the fireplace, but this cannot be identified as a general characteristic.

The Organization of Roasting Places in jernvinna

The roasting of bog ore was carried out either where the ore was collected or close to the furnace. There are advantages and disadvantages with either. After roasting, the ore becomes considerably lighter and thus more easily transported. However, the roasted ore has to be kept dry and therefore needs some form of cover after roasting. In 1777, Captain Oppen described the preparation and smelting of iron in Østerdalen. He relates how the ore was collected from the bogs and dried on the spot before being carried in the frost season to the iron-extraction sites for roasting. Several other older sources likewise refer to the transportation of unroasted ore.¹³⁶ These sources agree nicely with the picture from Dokkfløy, where roasting appeared at the production sites, and often beside the integrated charcoal pits. The reason for the position alongside the charcoal pits is taken to be linked to the shared use of a wood supply. It would be most efficient and least wasteful of resources to undertake the roasting here where it could be included as a stage in the preparation of charcoal wood. The offcuts from that could therefore be used for roasting.¹³⁷ At Dokkfløy, however, no systematic searches for roasting places out in the landscape have been undertaken, and it is uncertain whether there was any roasting at sites other than the production sites. Under the Rødsmo Project, consequently, charcoal pits were used as a guide for the location of roasting.¹³⁸ Beneath the bank of a charcoal pit concentrations of roasted ore were also found. The interpretation in this case is that scrap wood from the charcoal timber was used for roasting. The stratigraphy, however, is a problem, as the roasting must have been carried out before the pit was constructed.

In my view, an argument against shared use with charcoal pits lies in access to fuel, especially in areas where the activity was intensive. Based on written sources from the eighteenth century, Pettersson¹³⁹ points out that roasting fires in Norway were square or rectangular with a length of 1.9–6.2 m. Calculating using lengths of logs, Evenstad works with a fire of fully 36 m², which Pettersson suggests was probably a figure produced at the writing desk, as it bears little correspondence with the quantity of ore used in smelting.

¹³⁶ Pettersson (1982) 49, with refs.

¹³⁷ Narmo (1996a) 67–68.

¹³⁸ Narmo (1997) 83.

¹³⁹ Pettersson (1982) 53.

Schultze¹⁴⁰ works with a fire of 13 m².¹⁴¹ The point is that, irrespective of which of these sizes is used, left-over wood from charcoal timber alone will not provide enough fuel. Narmo¹⁴² has made calculations of how much wood would be needed for roasting to be carried out. The largest roasting place in his studies needed 2.8–6.5 m³ of fuel, which again is far more than offcuts from charcoal-making.

In contrast to other, earlier, sources, Evenstad reports that the ore was roasted where it was gathered, and Schultze relates that the ore could be roasted either where gathered or by the furnace. In Tranemo too, roasting places were located both at the source of the ore and at the bloomeries.¹⁴³

In the Gråfjell area there is only one case where roasted ore was found right beside a charcoal pit. Otherwise, the picture is one of the position of roasting places and charcoal pits seeming *not* to coincide. The organization, on the contrary, follows two different patterns, with the charcoal pits lying as a ring around the production sites while the roasting places lie in groups in the places where bog ore forms. In my opinion, the distribution is linked to the level of production, according to which the enormous level of roasting also meant a huge demand for wood. The woodland in which the roasting places were located was consequently reserved for this activity. During the later analysis of the volume of production, the need for ore is also included. Here it is calculated that three roasting places of the size of Rp.18 were needed to use up the charcoal from one average charcoal pit (8.3 m³, see Ch. 6, The volume of charcoal production). This corresponds to a minimum of four m³ of timber, which is about half the output of one charcoal pit.

The sources of ore were thus determinative of where roasting was carried out. The bog ore was taken right out of the bog and carried to the nearest dry ridge or raised area where it was dried and roasted. In some cases, however, roasting places have been found alongside the bloomery sites. An example is Jfp.30, where there were 18 roasting places. Searches have been carried out with a magnetometer in the surrounding area and in total 44 roasting places were found within a 200 m radius. In this area, however, there were also copious sources of bog ore right up by the site, and roasting both at the production site and in the immediate vicinity is explained by access to the resources. However, there are no charcoal pits in the immediate vicinity of Jfp.30, which reinforces the hypothesis of the planned use of woodland resources.

140 Schultze (1732).

141 See Pettersson (1982) 57.

142 Narmo (1996a) 64–66.

143 Englund (2002) 185.

Concluding Discussion

The investigations of the roasting places have produced both new and good results. Starting from NIKU's survey results, searching by magnetometer was developed further, resulting in a number of discoveries. A comprehensive survey in the whole Gråfjell area had, meanwhile, led to many more finds. Considering the relative consumption of charcoal and ore there must have been several thousand roasting places around the landscape.

The studies of roasting places have produced information on form and variation in size, while constructional elements which indicate the process have also been found. The roasting places as individual ancient monuments are not what is most interesting in this regard. More important is the knowledge obtained concerning positioning, distribution pattern, and number/extent. This, when compared with the distribution of bloomery sites and charcoal pits, makes it possible to understand *jernvinna* as a larger whole.

Organization and Exploitation of Resources

Earlier in this chapter I have shown how technology and organization at the bloomery sites is based upon one and the same concept, with its roots in a definite system. It remains, though, to discuss the organization within the landscape. The mapping of bloomeries, charcoal pits and roasting places is well suited to landscape analyses. As Figure 3.51 shows, ironmaking took place in the southern part of the Gråfjell area. The Gråfjell area is varied both in topography and in vegetation. In the south, flat pine moors, large boggy ridges and low raised areas are predominant (Fig. 3.52). The terrain rises to the north and the landscape becomes more uneven. There are still large flat bogs, but the hillside bogs are more dominant. Mixed woodland and spruce forest take over the range of vegetation (Fig. 3.53). The natural environment should, in my opinion, be regarded as a determinative factor in how *jernvinna* should be understood in its entirety. The distribution of the bloomery sites is clearly conditioned by the topographical circumstances. Common features are physical factors such as the size of the sites, their distance from one another, their proximity to woodland resources, and access to communication routes. As pointed out, there is a tendency for the largest and most complex production sites to be found in the southern part of the area while smaller sites lie primarily in the more uneven land further north. The boundary line around which the sites change character is a fluid one, and largely follows the topographical and vegetational variations. The largest sites are found in flat and easily accessible terrain while small sites are usually to be found in areas of more hilly and

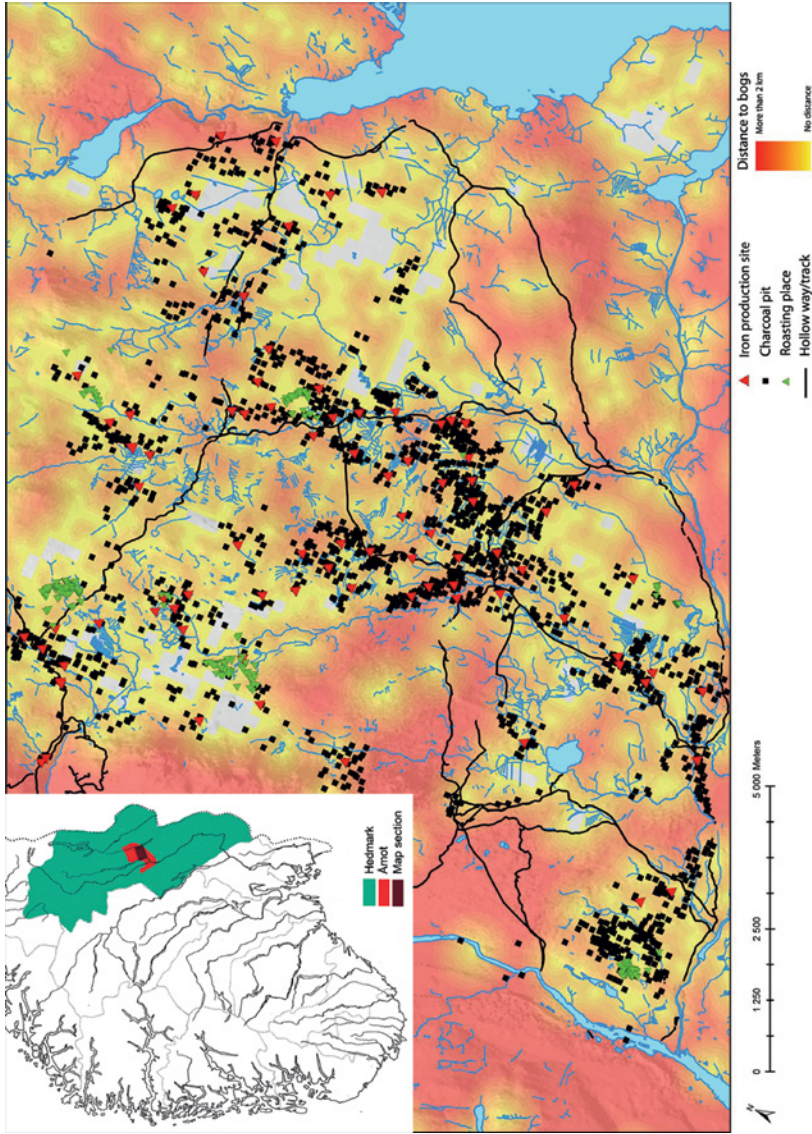


FIGURE 3.51 Map of all the recorded bloomeries, charcoal pits and roasting sites in the Gräffell area. The map is based on the surveys undertaken by NIKU and Smekalovs. The distance from bogs is represented by differences in colour shade (bog is white; red more than 2 km away). Note the positioning of the roasting sites in hollows between flat bogs. The map also includes hollow ways and old routeways plotted on the military reconnaissance map of 1802
MAP: D. HILL, MCH



FIGURE 3.52 *Typically flat pine moor landscape with low morainic ridges in the south of the firing range. The undergrowth consists principally of moss and heather. A charcoal pit was placed up on the ridge; a typical position, to avoid dampness*

PHOTO: B. RUNDBERGET, MCH



FIGURE 3.53 *The forest gets denser in the north, with spruce taking over and dominating the vegetation. The undergrowth is thick, consisting of scrub and bracken. The landscape becomes steeper and more uneven at the same time*

PHOTO: B. RUNDBERGET, MCH

difficult terrain. Medium-sized sites are normally found in areas with a less consistent landscape.

Typical examples of large production sites in the south are Jfp.9, Jfp.12, Jfp.14 and Jfp.30, all of them sites which comprise more than one standard model. Bloomery sites such as Jfp.10, Jfp.15, Jfp.17 and Jfp.31 represent small and medium-sized sites in the northern part of the area of study. These sites represent one basic or standard model. Jfp.23 and Jfp.32, however, are examples of larger sites, even in the north. The former consists of a basic model and a standard model, as the only one in the north, while the latter has a typical standard model. In contrast to many of the smaller sites in the north, these two are sited in relatively flat and readily accessible terrain, and thus confirm the landscape-determination of distribution. In the south, only two small sites are known, Jfp.11 and Jfp.37.

The distance between bloomery sites is another variable. In the south, the sites are usually several kilometres apart. In the north, they are more closely spaced, at distances varying from 100 to 500 m. In the case of medium-sized sites, the distance is rather greater. The southern area can be described as being characterized by a form of symmetry, with relatively regular spacing. In the north, that pattern breaks down and the picture is characterized by apparent disorder.

The reason for this variation has to be discussed. The dates show that many of the sites in the south began around AD 1100, earlier than many of those in the north. Of the earliest dated bloomery sites in the north, meanwhile, two of them are the large production sites Jfp.23 and Jfp.32. There is thus a clear preponderance of large sites with an early date. It should be noted here too that activity at these sites continued over a longer period than at the smaller ones. At the same time, several of the earliest dated sites have been found in the north, sites that were used in the eleventh century. A relocation of activity over time, for example from the south to the north, thus seems implausible (see Ch. 5). An interpretation of the variation in distribution and size has therefore to be sought in the local, topographical conditions. In the south, on the flat pine moors where access is easy, and in certain areas in the north, the iron-smelters kept to the same site for a markedly longer time than was usually the case in the north. When the slag heaps had reached a size which made further deposition difficult without slippage, the ironmakers just moved a few metres to the side and production was kept going. Further north, where the terrain becomes gradually more uneven and harder to move around in, the life-span of each site was significantly shorter. The slag heaps are smaller, and on that basis extraction could have been kept going over a longer period. As that did

not happen, I infer that the high number of sites in the north represents more frequent relocation, normally by just a few hundred metres.

I believe that the reason lies in access to woodland. In the north, the nearby timber sources were swiftly used up and, since the production sites are characterized by few fixed installations, it may be that it was more efficient to move to follow the timber than to bring the timber to the production site. In the south, the opposite is the case. The sites fetched timber from greater distances and over a longer period of time. The terrain seems thus to have been decisive in how long production was kept going at each production site. In easy circumstances, distance was no issue, but when the landscape became more hilly and difficult to access, it was more efficient to move to follow the sources of wood. According to this hypothesis, the somewhat messy distribution of sites in the north appears more logical.

The positioning of the charcoal pits in relation to the bloomery sites lies at the heart of interpretations of the organization within the landscape. Several factors influence where the charcoal pits are placed, including the presence of bog, the slope of the land and the nature of the ground. Most important, however, is the connection with timber resources and the distance to the bloomery sites. In the Gråfjell area, the charcoal pits lie as a ring around each bloomery site. The distance between the production sites and the charcoal pits varies from very close proximity to up towards 600 m; in a few cases the distance is even greater. The number of charcoal pits varies, and this reflects the volume of production at the individual sites.

The association of the charcoal pits with production sites is clearest in the south where the ironworking sites are more spaced out. When the production sites are densely clustered it can be a challenge to associate the pits with the correct site. To some extent, the size of the production sites can provide an approximate estimate of how many charcoal pits should be associated with the site, and a rough allocation can be undertaken on this basis. NIKU linked the bloomery sites and charcoal pits together, and on the whole their mapping agrees well with the excavation results.

The system involving one bloomery site in the centre and a ring of charcoal pits in the surrounding landscape testifies to a form of organization that had been thought through before production began. The production sites may appear, in effect, to have been provided with a circumference within which the timber was reserved for the site in question. Such conditions could have been the norm throughout the area, even in the north, although topography and access were decisive with respect to distance and to whether one decided to relocate production within an area. The number and distribution of charcoal

pits thus represent two important factors: the volume of production and the organization of iron extraction on the basis of the need for wood.

Compared with the ironworking sites and the charcoal pits, which can be described as having a wide distribution in the landscape, the roasting places had a different distribution. The factors determining their location derived from the special topographical and geological circumstances which govern the precipitation of ore. In contrast to timber, ore is a resource that is not found everywhere. The distance from the ore-source to the bloomery site can therefore be great, in some cases several kilometres. Thus it was not the source of ore but that of the wood that determined how iron extraction was organized. The wood for charcoal making and ironmaking was found in the vicinity of the production site, while the timber at the ore-sources was reserved for roasting. Where the roasting of bog ore was on a large scale there are few, if any, charcoal pits.

An example of this form of organization is found in the northern part of Vestre Jernskallia (Fig. 3.46). The area is characterized by hillside bogs and dry morainic ridges. On the latter, timber grows well, and the ridges are well suited to charcoal-making. Charcoal pits are commonly found on such ridges. In this large area, however, not one charcoal pit has been found. Through magnetometric survey, on the other hand, within an area of less than 500 m, 70 roasting places were found, of which 24 were single roasting fires and 46 roasting places with several fires. Only a small part of the bog area has been surveyed and the number of roasting places will be much higher. The absence of charcoal pits and the extent of roasting activity manifestly show that the wood resources were used for roasting.

This part of the Gråfjell area is also quite special as several place-names point to iron extraction, outcrops of ore and roasting.¹⁴⁴ The high area to the east is called *Jernskallen* ('Iron skull'), and around the southern part of Jernskallen a number of bloomeries have been identified. To the north, however, it is practically void of finds, in terms of ironworking sites and charcoal pits. Here, the collection and roasting of ore was the principle activity. The local names *Malmmyra* ('Ore bog'), *Raudfjellet* ('Red mountain') and *Eldmyrene* ('Fire bogs') bear witness to this. *Raude* (*raud̥i*, 'red') is an old word for ore and recurs as a name-element with bogs in many parts of Norway.¹⁴⁵ *Elde* ('to fire') is a common word for roasting.¹⁴⁶

144 Harsson (2000) 32.

145 Stemshaug (2008) 58.

146 Evenstad (1782); See Stemshaug (2008) 60.

The spatial organization of *jernvinna* in the landscape must, as I interpret it, have been agreed and arranged within the local community, as is also implied by the uniformity of the production sites and charcoal pits. Three factors in particular support this argument. There is the distribution of the bloomery sites, which is governed by the need for timber. There is the exploitation of timber resources, which was governed by the need for roasting and iron extraction. And there is the access to and the exploitation of ore resources. As discussed above, the distance from the ore-source to the bloomery sites varies. Some sites were placed a long way from the nearest source of ore. That the ironworkers at these sites had a right to the bog ore shows that there was no common right of claim as the old communal regulations assert.¹⁴⁷ Ancient customs show that an individual or a farm had a right to resources, preserved by unbroken activity. I would assume that for individuals, it must have been most convenient to claim a right over the sources of ore and the nearby forest. Such a tradition of claims cannot, however, have been fundamental in the Gråfjell area, as the sources of ore were openly accessible resources. This is supported by the fact that a common custom accompanies the right to the ore sources, together with agreement that the timber in the neighbourhood of the ore sources was to be used for roasting.

The order is based upon a form of common property within a system that appears to have been determined in advance of production. That this was a planned economic enterprise is also shown by linking known old hollow-way networks and historically known roads from old military maps with the distribution maps. The road systems are topographically governed and were probably a basic factor in where the bloomery sites were located. The sites are very often located close to the road systems (Fig. 3.51).

The technology, the use of the landscape and resources, and the extent of production, appear to me to be factors which indicate a business in which the agents of *jernvinna* functioned within a wider, organized community, for which rules and customs in the use of raw materials were a key element. On several levels, the technology and organization show that there was a high level of knowledge of methods of iron extraction, of the exploitation of resources, and of communication. The uniform tradition that is reflected in the bloomery sites and the charcoal shows that there was a common basic concept which governed production. If a number of individual actors had operated individually, the system and the form of production would surely have appeared differently. The minor variations which the evidence nonetheless reveals, I see as the

147 Solem (2003).

result of there having been many actors who made individual choices, albeit within the framework of what the system would allow.

An alternative interpretation could be that the production reflects a large-scale activity in which a group of actors, possibly slaves or freed men, were working under direction, for the sheer profit of chieftains or the king. But such a system, and at such a scale as the evidence indicates, must have had a high degree of specialization (see Ch. 8), and a large administrative apparatus, of which there is no sign in the evidence. I consider, therefore, that iron extraction in the Gråfjell area should be seen in terms of there having been a consistent group within a large system, based upon communality and identity, which organized and carried out production.

Such a system, as I understand it, cannot function without some form of political control. Although I reject the idea of directly governed production, I do believe that there must have been a body behind it exercising some form of supervision. The reason for this is that I regard it as improbable that farmers and the agents of bloomery ironmaking would themselves have had a sufficiently good apparatus and network to manage the business, and especially what it leads to: the marketing of the product. Here it should also be noted that I do not see this system as having been unique to the Gråfjell area but rather the norm for the whole Hedmark tradition (see Ch. 4). Behind a homogeneous smelting practice with so large a regional base and with so many participants, there must have been a chieftain, king or group of landlords who controlled both the system and the distribution of iron through underlying rights and duties. This form of control, however, cannot realistically have been direct, precisely because of the dimensions the business had. For this reason, I consider it most plausible that the control was indirect, through a system in which tax, trade and exchange were components of the economic system. These considerations are fundamental and central for the remainder of this study and will be discussed further. However, before I return to this topic, it is necessary to undertake some detailed analyses of the extent of the Hedmark tradition and its place in time and space.

A Regional Tradition

The aim of this chapter is to give an account of the distribution of the bloomery ironmaking tradition that has been discovered in the Gråfjell area. One objective, in addition to determining its technological boundaries, is to estimate the extent from the number of bloomery sites and their size. The distribution also makes it possible to look at connections with other social structures. Furthermore, both potential core areas and areas of limited production can be defined. Radiocarbon dates have been obtained in many cases. These can contribute to the development of an insight into possible chronological variation. A key aspect is also how the distribution here compares with other iron-producing regions.

The Source Material

A main source of data is Riksantikvaren's database Askeladden.¹ From the archaeological sites recorded, it is possible to suggest the distribution and limits of *jernvinna*. The records, however, are far from complete, and representativity varies from municipality to municipality. This is very clearly shown by the patchy records of Economic Mapping in the 1980s and the Outlying Surveys in the 1990s. The data entered is also of highly varying character in terms of the level of information. Sites included in the present review are therefore only those that are either absolutely secure or very probably so in terms of the following criteria: Slag heaps (size, number, organization and form), slag typology, position in the landscape, and charcoal pits (form and organization).

In addition to searching the database, I have carried out surveys in areas where there is little information and where, in my judgement, it is necessary to confirm the quality of the data in Askeladden. These surveys have been particularly important in testing my hypotheses concerning type and organization. It has not been possible, however, to review every area. Despite this, I consider that the counts and interpretations which follow provide a plausible view of the distribution of the Hedmark tradition.

A second key source is the information found in topographical archives. These contain information that has not previously been used. It is principally

1 <http://www.riksantikvaren.no/Norsk/Askeladden/>.

made up of letters, newspaper articles, and recording undertaken on local initiatives.

A third key source is works, books and articles on local history and topography. Not all areas are equally well covered, and many of the texts are dated, embodying ideas that are no longer current. This literature nonetheless provides evidence of distribution, extent and technology in various parts of the study area.

The review is partly presented municipality by municipality, and partly area by area, as Askeladden and the topographical records largely conform to those boundaries. Altogether, 14 of these administrative districts are included in the analysis, with Rendalen as the northernmost and Eidskog the southernmost (Fig. 1.1). More than 600 bloomery sites and 6,000 charcoal pits of the Hedmark tradition are known.

South Østerdalen

South Østerdalen comprises the municipalities Rendalen, Stor-Elvdal, Trysil, Åmot and Elverum. North of Rendalen lies Alvdal, which is in North Østerdalen. The boundary between the north and south is approximately the same as the old boundary between *Opplandene*² and Trøndelag that ran past Hanestad in Rendalen. *Jernvinna* in the Viking Period and Middle Ages is found over much of the area, but the topographical context creates differences in both density and extent. There are also variations of a non-topographical character.

Rendalen

In Rendalen, sites of the Evenstad type are predominant,³ but charcoal pits and bloomery sites of the late Viking Period and Middle Ages have been recorded. Amongst other things, the author Jacob B. Bull⁴ describes finds of smelting slag. The author Per Hohle⁵ describes much of the slag from Rendalen as flowing slag that has been tapped from the furnace. Only a few sites of this type have been identified through 'Outlying Surveys'⁶ and on the basis of this

2 *Opplandene* is a historical term for the district north of the Oslo fjord. The region included the five old counties Gudbrandsdalen, Hadafylki (Toten, Land, Hadeland and Ringerike, Heinafylki (Hedemarken and Gjøvik), Rauma-fylki (Romerike and Glåmdalen), and Østerdalen. More recently, *Opplandene* covered the two counties Hedmark and Oppland.

3 Bårdseng (1994) 8; Espelund (1997).

4 Bull (1916) 263–264.

5 Hohle (1993).

6 Bårdseng (1994).

evidence I think that bloomery ironmaking in Rendalen in the Middle Ages was limited.

The northernmost known site of the medieval type (id 19985) is 7 km east of and at the same level as Bergset (Fig. 4.1). This site was recorded by Espelund in 1989. I have examined the site and, like Espelund, identified two slag heaps about 6 m apart. One of the heaps was oval and one round. A hollow close to one slag heap in the area between them shows the location of the single furnace. The slag was primarily tapping slag of the Hedmark type. In addition to tapping slag, fragments of base slag were noted. One of the slag heaps is dated to AD 970–1030 (T-8731, 1030 ± 60 BP). Under examination, it became clear that the types of slag, the organization, the form and the positioning indicate that this was a site of the familiar Hedmark type. One site (id 114959) which is situated near Holla in the south of the district has two slag heaps and is in all probability of the Hedmark type. This is corroborated by the fact that a series of square charcoal pits are characteristically placed around the site. There is one further site, which has not been entered in Askeladden, recorded as being in the same area.⁷ A similar site (id 139930) has also been found west of Otnes. The site is typical of the tradition, with two slag heaps and charcoal pits around. There is also a stray find of a tapping cone from Unset.⁸ This has a local context and there was probably another ironmaking site close by.

One site (id 109657) which can also be securely assigned to the same period is situated beside Harsjøen on the western side of Rendalen and is datable to the Viking Period/Middle Ages. This site consists of a round slag heap with typical flowing slag. The site therefore has parallels in the bloomery ironmaking areas of Gudbrandsdalen. However, the charcoal pits in the area are square. The slag heap is also larger than the norm for heaps containing flowing slag and has more in common with the round slag heaps that have been studied in the Gråfjell area and at Rødsmoen. As this slag heap has not been excavated, the slag typology is uncertain, and the site is counted as being of the Hedmark tradition from other details.

Stor-Elvdal

In 1743, the parish priest Christen C. Kiær⁹ described old iron slag and regarded *jernvinna* as having been important to the farmers in the area far back in time. In more recent times *jernvinna* was still familiar in parts of this municipality.

⁷ Pers. comm. Per Olav Mathisen, 30 November 2009.

⁸ Espelund (2005) 134.

⁹ Kiær (1743 [2004]) 120.

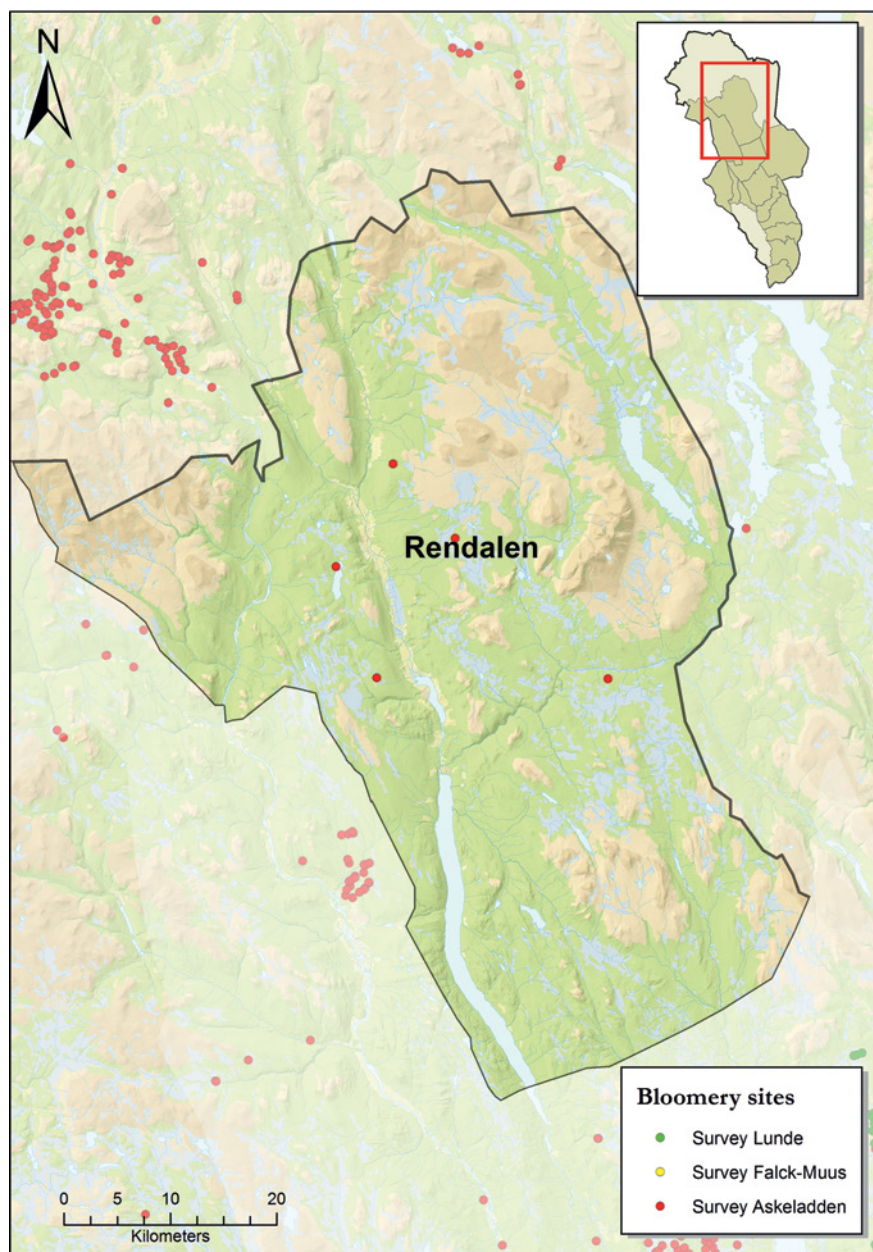


FIGURE 4.1 *The distribution of bloomery sites in Rendalen (after Askeladden) with sites referred to*

MAP: B. RUNDBERGET/M. SAMDAL, MCH

Anders Fosvold¹⁰ describes this tradition as an ancient industry that the unlimited resources, place-names and material remains bear witness to. He reports that bloomery smelting is known in several parts of the district. More recent mapping has confirmed this, and in total 35 bloomery sites from the end of the Viking Period and the Middle Ages has been identified. In an area six km north of the village centre of Koppang in particular there is a high density, with five bloomery sites and 30 charcoal pits.

At Øverdalssetra near Sollia in Atndalen, there is a bloomery site, id 31777, of great complexity (Fig. 4.2). Here, production from both the Early Iron Age and the Viking Period/Middle Ages has been found and recorded. The medieval site consists of two large round charcoal pits and two slag heaps. There was also a large circular waste heap in which the slag consists of large tapping plates and tapping cones. Recent survey work around Øverdalssetra shows that there is a series of sites and charcoal pits of the Viking Period and Middle Ages here. From the type of site and the organization, the pattern appears to have more in common with tradition in Oppland than with Østerdalen.

In Atndalen otherwise, the evidence is divergent. There are several sites that are probably medieval, and a number of charcoal pits that are primarily round in shape at the base corroborate this. The form and size of the slag heaps implies that these are sites with flowing slag. The contact network involving iron-makers in this area thus appears to have been rooted in Gudbrandsdalen. This makes sense, as Sollia was formerly part of Ringebu.¹¹

That apart, those parts of Stor-Elvdal that run up to Atneaset were part of Åmot in the Middle Ages (see Ch. 7, The written sources). This is also reflected in the bloomery ironmaking evidence. Stor-Elvdal west of the River Glomma has not seen much recording, but individual surveys show that the density was very low. The ironmaking sites furthest to the west in the district, which are probably of the Hedmark type, lie in Eldådal and just by the shieling of Gåla. Both sites, id 35585 and a site not entered in Askeladden,¹² consist of a slag heap immediately alongside a square charcoal pit. Typical tapping slag is found at both sites, indicating a connection to Østerdalen. Another bloomery site, id 75814, which is located in Imsdalen is a special one. The slag heap is roundish, low and inconspicuous, and the slag consists of flowing slag. Associated with the site are two roundish charcoal pits. Both the site and the charcoal pits point to contact with iron producers in Gudbrandsdalen.

¹⁰ Fosvold (1936).

¹¹ Schøning (1775 [1980]) Gudbrandsdalen, p. 131; Hiorthøy (1785 [1990]); see Larsen (2009) 121.

¹² Documented in the 1950s, resurveyed by Tryggve and Unni Bernt in 2014.

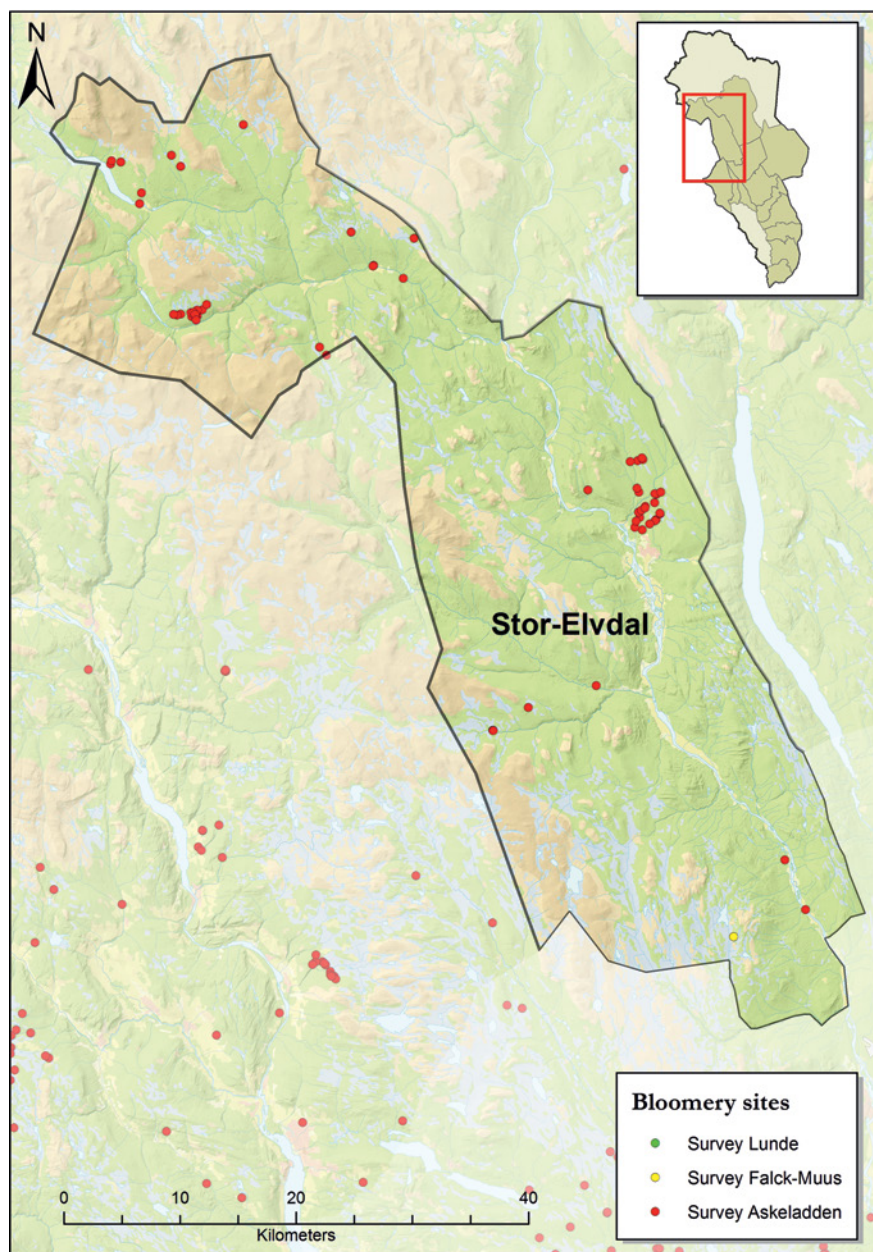


FIGURE 4.2 *The distribution of bloomery sites in Stor-Elvdal (after Askeladden) with sites of the Viking Period and Middle Ages referred to. Sites of the Hedmark type occur east of the Glomma, while sites of the Dokkføy type dominate in Sollia and west of the Glomma*

MAP: B. RUNDBERGET/M. SAMDAL, MCH

The area west of the River Glomma contrasts sharply with the Koppang area east of the river, where, as noted, a large number of bloomery sites and charcoal pits have been recorded.¹³ The extent and distribution of these is uncertain as only smaller, selected areas have been recorded. The area north of the centre of Koppang is the best mapped but a number of charcoal pits have also been identified east of the centre. The high density of sites can, quite reasonably, be linked to the old trading site (*Kaupang*) at Koppang (see Ch. 7, The written sources) which was described as the ironmakers' 'Bourse' several centuries before Evenstad.¹⁴ The structure and organization of the sites around Koppang, both the production sites and the charcoal pits, are classically of the Hedmark type.

There have been no excavations of bloomery sites in Stor-Elvdal. There are a few 14C dates in addition to that already noted from Sollia. A site consisting of two slag heaps at Blesterbekken north of the village Koppang (id 40115) is dated by Espelund to AD 990–1155 (T-10364, 980±70 BP). Close to this site are six charcoal pits, of which one is dated to AD 1265–1375 (T-10365, 695±65 BP). In connection with the construction of a new water treatment plant at Koppang, 14 charcoal pits were recorded, two of which were excavated. One was rectangular and one square, and they are dated, respectively, to AD 1035–1220 (T-18462, 905±60 BP) and AD 1165–1280 (T-18463, 830±75 BP).

Trysil

In 1784, the priest Axel C. Smith wrote about the large number of charcoal pits and heaps containing iron slag which were found in the forests in Trysil. This activity was largely associated with post-Reformation *jernvinna*, with, amongst other things, Swedish ironmakers crossing the border from Lima in the seventeenth century in order to exploit the resources after their own had become exhausted.¹⁵ In the 1950s, the agronomist Harald Lunde undertook surveys of Trysil district, finding hundreds of animal traps and between 200 and 300 smelting sites¹⁶ (Fig. 4.3). It is not straightforward to interpret what Lunde recorded as the distribution map clearly shows that charcoal pits have been recorded as bloomery sites. As a result, the real number of bloomeries and charcoal pits in Lunde's evidence is uncertain; however, it can be suggested that 25–50 (10–20%) should be bloomery sites. Despite this error, the survey

13 Bårdseng (1994), (1998).

14 Hohle (1993) 6.

15 Smith (1784 [1966]); Helland (1902) 549–550; Falck-Muus (1935); Matsson (1969).

16 Lunde (1977).

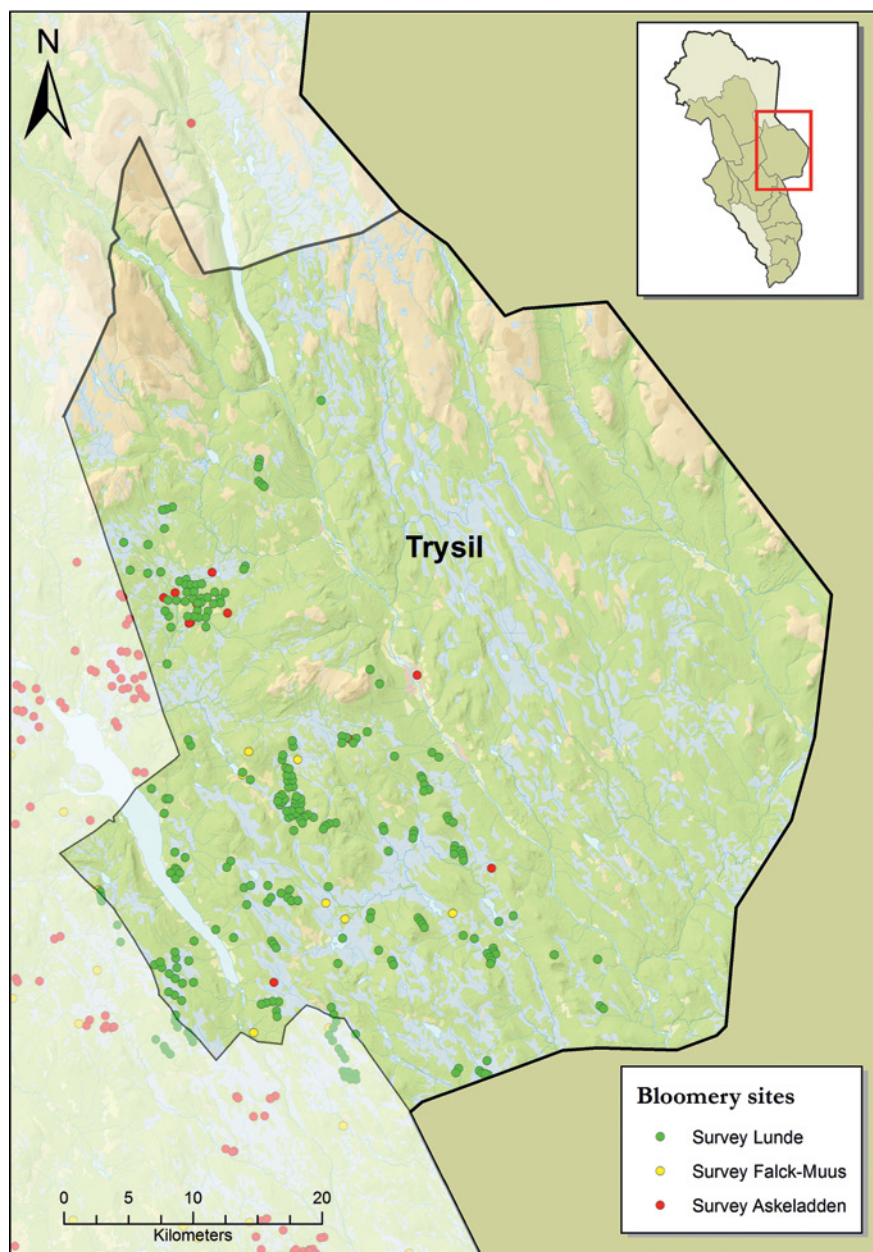


FIGURE 4.3 *The distribution of bloemery sites in Trysil (after Askeladden) with sites referred to, also including the surveys of Falck-Muus (1927) and Lunde (1977)*

MAP: B. RUNDBERGET/M. SAMDAL, MCH

results are of value, as the distribution of the smelting sites shows the extent in unrecorded areas.

The archaeologist Magne Thorleifsen¹⁷ has claimed that east of the River Trysil no charcoal pits or bloomery sites of the Viking Period and Middle Ages have been identified. This conclusion agrees well with the distribution of charcoal pits in Askeladden and with Lunde's recording. They all lie in the western parts of the municipality. This distribution is thought-provoking and cannot be determined by the absence of resources, as a number of the sites representing Early Modern *jernvinna* have been recorded east of the river.

Nine bloomery sites can be assigned to the Hedmark tradition with certainty. Six production sites lie near Slettås, one at Brunhøgda, and the other two to the south of the municipality. From Lunde's mapping, large parts of the landscape west of the Trysil River comprise a large number of smelting sites, and the number of bloomeries here is considerably higher than the figures we have at present.

Very few archaeological excavations have been undertaken in Trysil, and only one bloomery site (id 39958) has been dated.¹⁸ This site lies seven kilometres south-west of Innbygda, in terrain sloping to the north. From my examination, I concluded that the production site consisted of two parallel slag heaps (Fig. 4.4). The distance between these heaps is about seven metres. The site is low-lying, in slightly sloping terrain, and the measurements are difficult to confirm as the natural ground is uneven. The slag heap to the south has a bank of slag which extends the heap to the west. The production zone lay between the heaps, and a hollow by the southern heap is interpreted as the remains of a furnace. Roasted ore was found between the heaps. In the surface of the northern heap lay several large pieces of tapping slag. The northern slag heap is dated to AD 1165–1275 (T-8737, 805±75 BP). There are several charcoal pits of a square shape surrounding the site. 300 metres north of the site there are rich sources of ore.

One charcoal pit was investigated in 2010. This pit is typical of the tradition involving a square base. Two 14C dates, from the base of the kiln and the bank respectively, are calibrated to AD 1220–1275 (TRa-1880, 805±30 BP) and AD 1170–1230 (TRa-1881, 855±30 BP).

On this basis, I would conclude that iron production west of the River Trysil is primarily from the medieval period, while production east of the river has to be associated with the late bloomery ironmaking that was undertaken

¹⁷ Thorleifsen (2002).

¹⁸ Espelund, letter of 27 September 1998.



FIGURE 4.4 *Ironmaking site id 39958 near Brunhøgda in Trysil. The site consisted of two slag heaps of which that to the north (pictured) was large and clear*
 PHOTO: B. RUNDBERGET; MCH

primarily by Swedish ironmakers. The density is greatest in the forest areas towards Lake Osensjø and Åmot Municipality, and in the south-western area.

Åmot

Jernvinna in Åmot is very well mapped. Outside of the Gråfjell area and Rødsmoen,¹⁹ more than 50 bloomery sites and 600 charcoal pits have been identified (Fig. 4.5). The number of ancient monuments implies that iron production is of the same extent and complexity as in the Gråfjell area. South of Rena and on the western side of the River Glomma, nine bloomery sites and 185 charcoal pits have been identified. This is the area with the lowest density, especially west of the Glomma. North of Gråfjell no bloomery sites are known. This is, naturally, linked to the topography, but, as I have shown, it also corresponds closely with Rendalen, where only one site is known. Outside of the Rødsmo and Gråfjell Projects, seven charcoal pits have been investigated. These charcoal pits are basically all interpreted as square. The 14C dates show that activity there belonged to the period AD 1025–1290.

These results show that Åmot had a central place in *jernvinna* in the Middle Ages. The distribution pattern also implies that the eastern part of the

19 Bårdseng (1994), (1995).

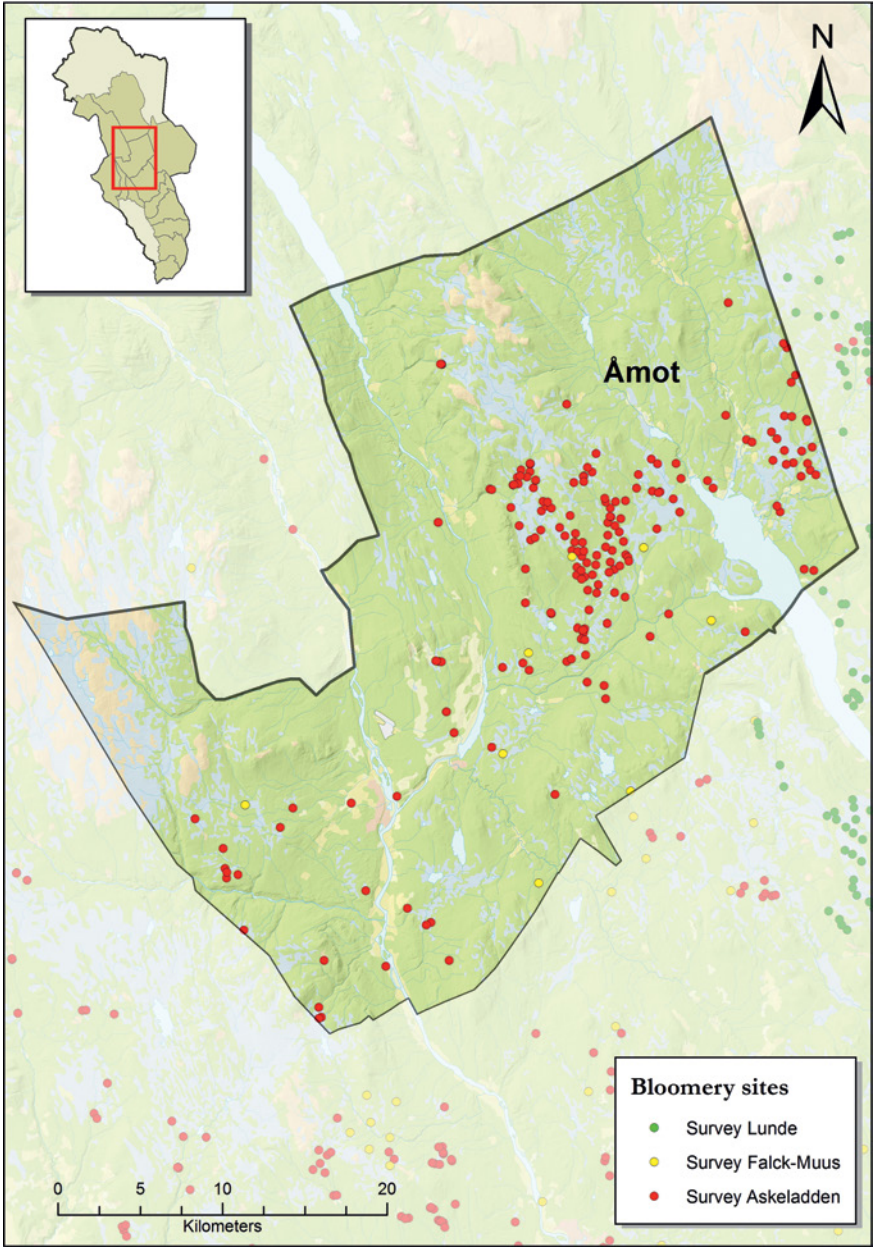


FIGURE 4.5 *The distribution of bloomery sites in Åmot (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931)*
MAP: B. RUNDBERGET/M. SAMDAL, MCH

administrative district has a greater density than west of the River Glomma, a feature that corresponds with what was found in Stor-Elvdal. The northern part of the district has no recorded sites. I regard this as a natural extension of the results in Rendal, where bloomery ironmaking activity was low.

Elverum

As in Åmot, there is a high concentration of bloomery sites in Elverum where 45 sites of the Hedmark type have been recorded (Fig. 4.6). Uncoordinated surveys have produced a picture with sites clustering in small groups. Nonetheless, sites have been identified scattered across the whole of the administrative district, implying a fairly even distribution.

The sites are for the most part recorded with two slag heaps, although everything from one to five slag heaps has been identified. The site id 113707, immediately north-east of the centre of Elverum, stands out with its very complicated structure involving a row of slag heaps which lie partly side by side and overlapping one another. The exact number is difficult to determine, but it is possible to distinguish at least nine large and medium-sized heaps. A few dozen metres away there is another, smaller site, with two oblong slag heaps, a number of charcoal pits, and two possible roasting sites. This bloomery site is the largest known to me, and I would roughly estimate the volume as over 300 m³, more than twice that of the largest site (Jfp.30) excavated in the Gråfjell area.

No bloomery sites in Elverum have been excavated. From a site at Malmholtet (id 29983), north of Elverum, a charcoal sample from spruce has been dated to AD 1225–1270 (T-10366, 775±45 BP).²⁰ This site is of the classic standard model with two parallel, oblong slag heaps.

A number of charcoal pits in this district have been investigated. Many of them are associated with iron production although several must be attributed to smithing activity on the basis of their location close to farms or on the sandy heaths along the River Glomma which are not topographically suited to ore-formation. There are no bloomery sites in these areas either. The charcoal pits have ¹⁴C dates corresponding to those for *jernvinna*. There are 52 ¹⁴C dates within the period AD 890–1395, three of which begin before AD 950, while only one has a terminal date post-1300. All of the charcoal pits that were investigated by machine had a square or rectangular shape.

²⁰ Espelund, letter of 27 September 1998.

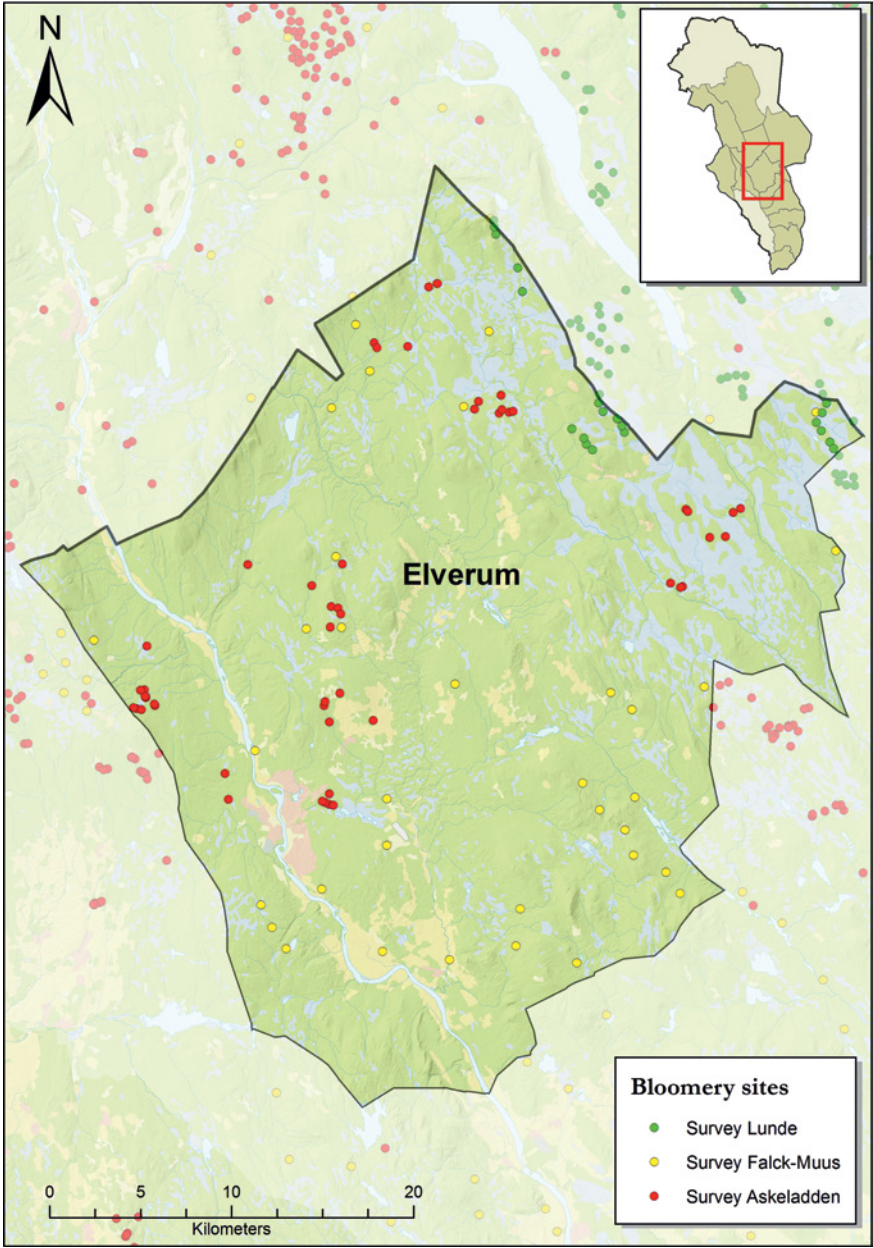


FIGURE 4.6 *The distribution of bloomery sites in Elverum (after Askeladden) with sites referred to, also including the surveys of Falck-Muus (1931) and Lunde (1977)*
MAP: B. RUNDBERGET/M. SAMDAL, MCH

Solør

Solør is a landscape that consists nowadays of the Glåmdal municipalities Våler, Åsnes and Grue, together with Brandval in Kongsvinger. Parish priest Paul B. Hammer²¹ reported *jernmyrer* ('iron bogs') in many places, and finds of slag show that iron was smelted here in antiquity. The priest and historian Olaf Olafsen²² reports many signs of iron extraction in Solør. The cultural researcher Eilert Sundt²³ also noted that in the forests there were heaps of ash and slag close to the bogs.

Looking at Solør as a whole, however, there is a clear difference in the distribution and extent of *jernvinna*. In the two northern municipalities, Åsnes and particularly Våler, the traces are plentiful. The density in Grue is somewhat less, and there are practically no remains in the two southern municipalities. In a study of the recorded evidence from the region, Holm²⁴ shows that charcoal pits are the most common class of ancient monument. She considers *jernvinna* in this region to represent the Viking Period and Middle Ages.

Våler

In Våler, the 'Outlying Surveys' identified 22 sites of the Hedmark type²⁵ (Fig. 4.7). Mapping has been undertaken in two principal areas of great density. The results to the north in Risbergmarka, up by the border with Elverum, are of interest. A number of sites have been recorded in Våler, but except for Falck-Muus's maps, no ironmaking sites are known in this part of Elverum. This clearly demonstrates the unnatural divisions that the boundaries of administrative districts impose. I consider the density of sites in this wooded area to be very high. From Askeladden, only 28 definite sites of the Hedmark tradition are known. But the figure should, in my view, be multiplied several times over, as indeed is shown by Falck-Muus's surveys in Finnskogen²⁶ (see Fig. 3.1).

The production sites in Våler usually comprise two slag heaps, though there are also variations in complexity here as well. One site, id 206360, in Risbergmarka, consists of three production sites, all with two slag heaps, within a radius of 50 metres. The area is practically perforated with charcoal pits and there are a number of bloomery sites in the vicinity.

21 Hammer (1743 [2004]) 88.

22 Olafsen (1916) 9.

23 See Helland (1902) 549.

24 Holm (2002) 32.

25 Bårdseng (1994), (1995), (1996b).

26 Falck-Muus (1927), (1931).

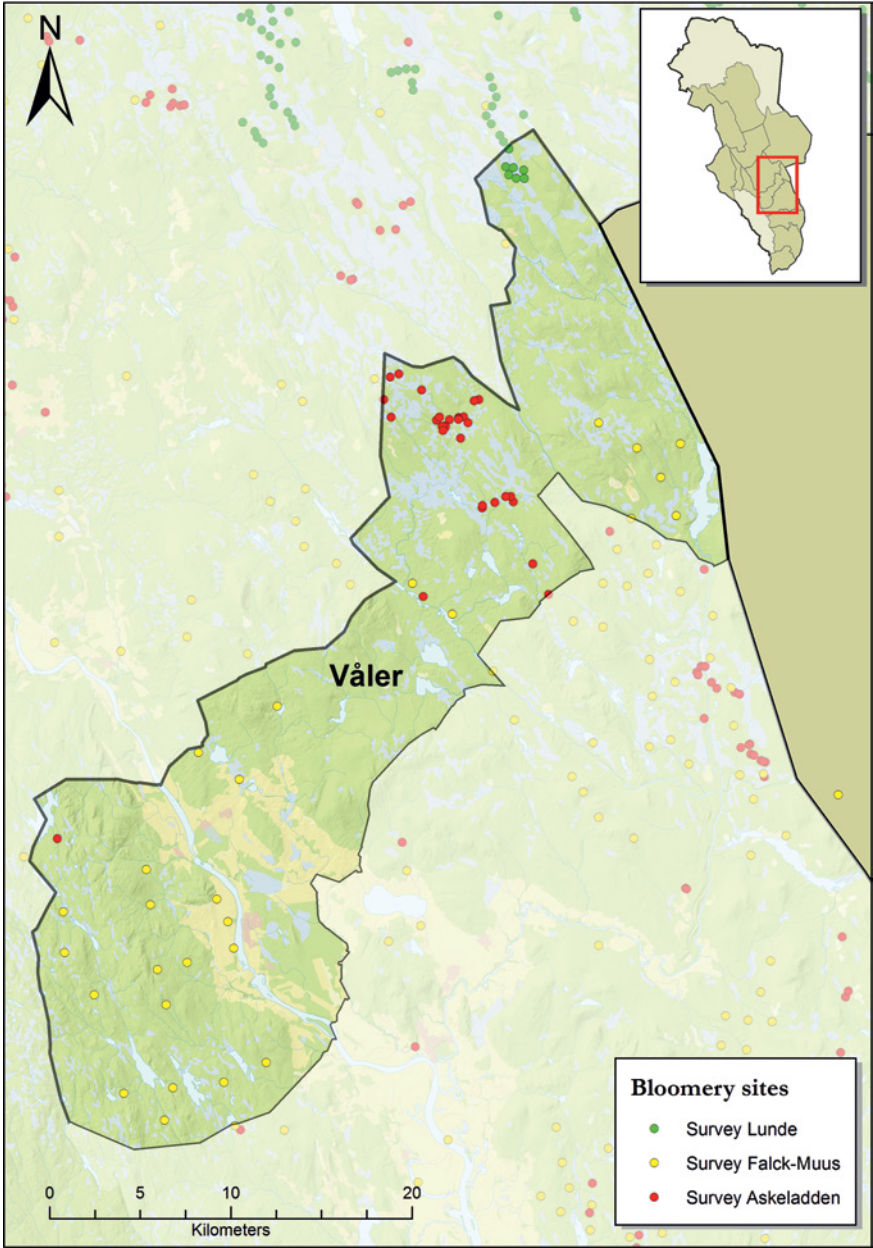


FIGURE 4.7 *The distribution of bloomery sites in Våler (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931)*
MAP: B. RUNDBERGET/M. SAMDAL, MCH

No excavations of bloomery sites in Våler have been undertaken. In Risbergmarka, Espelund has dated the bloomery site id 62320. This site had two loaf-shaped slag heaps with a volume of about 15 m³.²⁷ The site is dated to AD 825–890 (TUa-7032, 1180±25 BP), which is early. In addition, 25 charcoal pits have been investigated in Våler, and there are 20 14C dates, all of which fall within the period AD 1010–1290. All of them are square and, in contrast to Elverum, all can be associated with iron production.

Åsnes and Grue

In these municipalities, 36 sites are known that can securely be assigned to the Hedmark tradition, 26 in Åsnes and 10 in Grue. Several hundred charcoal pits have also been identified. In a number of regions there is a distinct surplus of charcoal pits, and the number of bloomery sites is much larger. Mapping shows that iron bloomery sites are spread over wide areas. The density is clearly highest in the eastern parts. According to Askeladden, the activity declines markedly to the south of Grue. Falck-Muus's surveys do not agree in this, and as few surveys have been undertaken, the density must have been greater than we can now see.

In 2012, a bloomery site (id 121321) was excavated. The site was cut by a road and only remnants of two slag heaps, a stockpile of ore and a fire place was left (Fig. 4.8). However, the organization clearly shows that the site consists of two oblong parallel slagheaps, which fit well with the standard model of the Gråfjell area. Slag was of the type tapping slag, and several base slags show that the furnaces were constructed with the characteristic isolation pit below the surface. Four 14C dates fall within the period AD 1030–1220.

Another site to the north in Åsnes is dated to AD 970–1195 (Beta-83436, 990±60 BP). At the same time, a charcoal pit associated with this site is dated to AD 1030–1290 (Beta-83435, 840±70 BP).²⁸ There are two further known sites nearby (Fig. 4.9), in addition to a series of charcoal pits.

In the north-east of Åsnes, the typical style of organization, comprising two oblong, parallel slag heaps, dominates. However, a few large sites with up to eight slag heaps have been recorded. Bårdseng²⁹ has estimated the volume of slag in the largest heaps as being from 30 to 100 t.

A change in the structure of sites which can be easily traced from the south of the Åsnes down into Grue is striking. The change can be seen in the structure of the sites, their positioning and the organization within the landscape.

²⁷ Espelund, letter of 4 October 2007.

²⁸ Gustafson (1995).

²⁹ Bårdseng (1996a) 15.



FIGURE 4.8 *Sectioned slag heap at bloomery site id 121321. The remains of two slag heaps, which made up a standard model, were identified. The heaps contained tapping slag, the remains of base slags, and slag with wood impressions. This shows that the furnaces had isolation pits beneath them*

PHOTO: B. RUNDBERGET, MCH

The interpretation of this change of the tradition rests upon 13 sites examined, 12 of which are interpreted as having their foundations in the Hedmark tradition. In contrast to the usual situation further north, several of these sites are located upon slightly sloping ground or on the end of low moraine ridges. With one exception, the production sites have two or more slag heaps. Apart from two sites that are typical, with a pair of parallel slag heaps, all of them are organized like Jfp.6 in the Gråfjell area, which is classified as a variation on the standard model. Only one site of this type was excavated in the Gråfjell area.

In shape, the slag heaps vary from round to oblong, and their size ranges up to 'large', with a height of more than a metre. The production zone is located on a flat surface on the higher side of the heaps, and the terrain has been deliberately exploited for ease of disposal. The use of the terrain is thus more in agreement with the structure of sites of the Early Iron Age. As discussed in Chapter 3, this means that there was a need for extra stockpiles. The organization implies that this activity may have been less methodical and intensive. It is also a point of interest that the majority of the sites are located close to ore-bearing bogs. This looks like a deliberate strategy, and I interpret the structure and organization as having been more individually governed and not subject to a

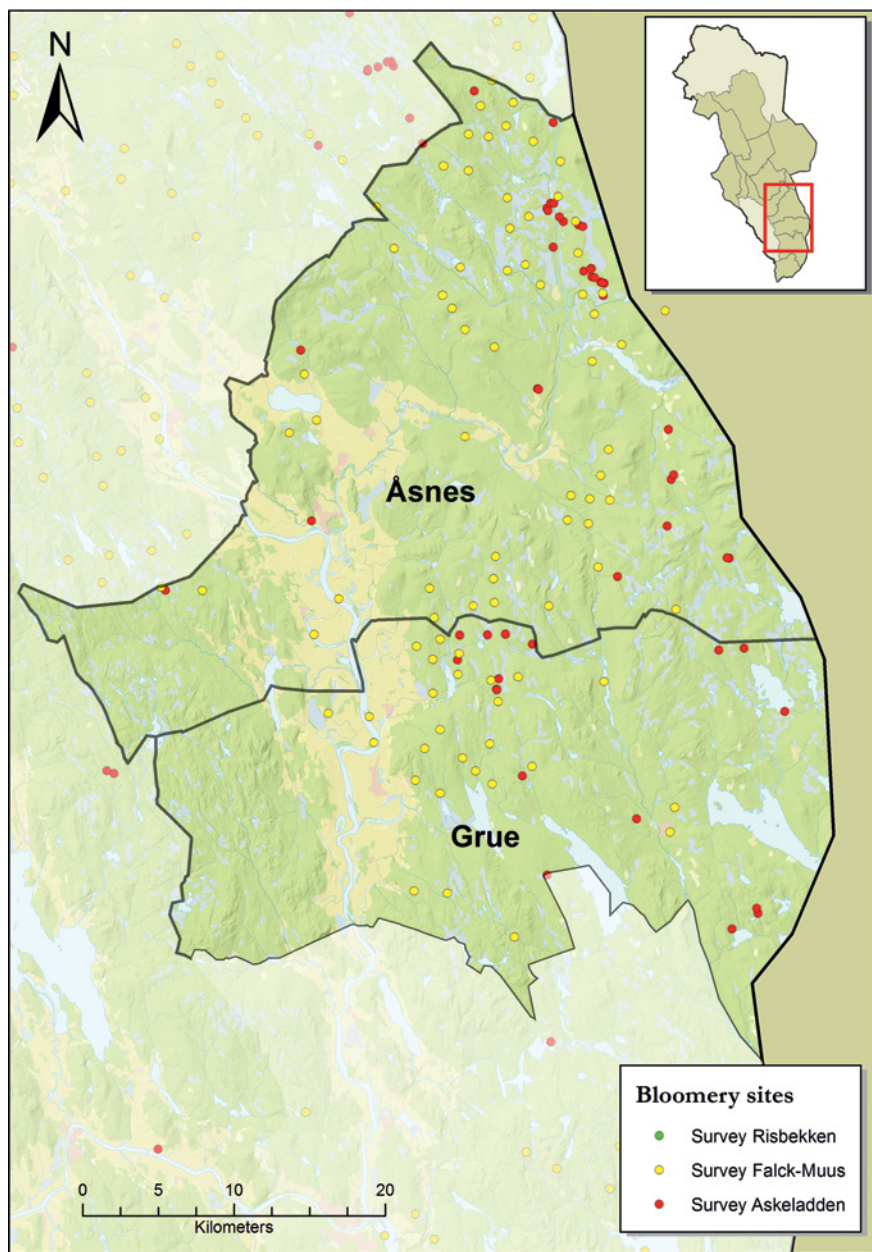


FIGURE 4.9 *The distribution of bloomery sites in Åsnes and Grue (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931)*

MAP: B. RUNDBERGET/M. SAMDAL, MCH

common system as we see further north. The variations between these sites are multiple, and the size of the production sites is generally smaller. Resources of wood were not a decisive factor in the selection of a production site as was the case in the Gråfjell area. At the same time, the ore resources appear to have been linked to individual sites. This indicates that the demand for resources, and so the level of production, was lower.

The variation in organization suggested possible chronological differences. The positioning in the landscape points towards an older style of production, and the somewhat unsymmetrical activity could also imply an early and less developed phase of the tradition. The positioning by ore bogs was a third element that diverged from the norm of the Hedmark tradition.

It was also quite striking that the few ¹⁴C dates available from the southern area were consistently a bit earlier than those from further north. Most of them fall before AD 1150, and two are as early as the ninth and tenth centuries. One charcoal pit has a ¹⁴C date to the first half of the thirteenth century. The ¹⁴C dates of the bloomery site in Risbergmarka are also early (AD 825–890). The ¹⁴C dates of several charcoal pits within the administrative district show that the principal period of use was AD 1000–1250. Because of the uncertainty concerning type and chronology, I have dated three of the sites that were examined. These sites were selected on the basis of their different characters as described below:

Bloomery site id 31853 was a complex bloomery located at the western end of a low, east–west, morainic ridge. There are at least five roundish slag heaps which to some extent have been thrown down from the ridge, to the north, the west and the south. The production zone lay on the flat surface between them and it would appear that production was relocated as the waste heaps became too large. It is difficult to say anything about contemporaneity and phases, but in light of the fact that the slag heaps are sited in some cases very close to one another, not all of the furnaces can have been in use at the same time. The production site is interpreted as a standard site of the Hedmark tradition, consisting of several basic and standard models. A trial trench was dug into one slag heap and in towards the furnace zone. The fill consisted principally of tapping slag and crushed tapping cones. There were also some crushed base slags and a little rust-brown furnace slag. A charcoal sample from the bottom layer was selected for ¹⁴C-dating. The sample consisted of a piece of charcoal that was divided into two between two annual rings. The curvature of the rings seems to imply that it is an outer part of the log that has been dated, and a large time-width can be discounted. The material was identified as pine and the slag heap dated to AD 1200–1250 (Tr-3093, 835±25 BP).

Bloomery site id 80087 was placed on a slope towards the south. This consisted of one visible slag heap and the production zone was located on a small terrace above the slag heap. Some tapping slag and shaft material lies on the surface. Several small mounds to the south-east are also identified in Askeladden as low slag heaps. Roasted ore was identified by boring east on the terrace surface. On the same terrace, there is also a square charcoal pit measuring 2.5×2.5 m. In a dip 30 m south of the site there is a large wet area with much bog ore. The position of the site and the use of the discarded slag diverges from the usual pattern of organization, but the slag types and the charcoal pits are congruent with the Hedmark tradition. The store of ore is also in a position that agrees well with this interpretation.

The trial trench was located in the centre of the slag heap right beside a depression thought to be the furnace zone. The fill consisted of tapping slag and some fragments of base slag. Towards the bottom was a layer of disturbed fill and below it was a 4–6 cm-thick layer of charcoal and slag. The charcoal sample was taken from the bottom layer. The sample consisted of several small pieces of charcoal and it is difficult to determine where in the wood it came from. The species was identified as pine and it was dated to the period AD 690–780 (Tr-3095, 1275 ± 25 BP).

Bloomery site id 78190 lies on an east–west running ridge in terrain sloping towards the south. It consists of a large, oblong slag heap aligned east–west. The production zone is sited on a flat surface immediately north of the slag heap and comprises a slight hollow that follows the long axis of the slag heap and is interpreted as a tapping channel. Some tapping slag can be seen. A similar bloomery site lies 40 m to the north on the northern slope of the ridge. In a dip south of the ridge there is a grass bog with high potential for bog ore. This ironmaking site is the only one with a single large slag heap. Its position and organization are reminiscent of id 80087, although there are no charcoal pits immediately alongside the production site. A series of square charcoal pits are found in the area around the two sites and the organization in this respect also appears to follow the norm of the Hedmark tradition.

The trial trench was placed in the centre of the length of the slag heap. The slag heap is very large and oblong (Fig. 4.10). Its length from east to west was 11 m and its width north to south 4.5 m. The height was 0.8 m above the furnace zone to the north and fully 1.8 m from the base of the slope to the south. The fill was very rich in slag, and dark. The slag comprised tapping slag and base slags. Towards the bottom was a large amount of shaft material with a curvature that implies a round shaft. Two fragments of charcoal from the same piece were taken from the bottommost layer. The annual rings in the piece of charcoal were relatively small, which may mean that the date is earlier than the true



FIGURE 4.10 *Slag heap at bloomery site id 78190. The slag heap has been sited on slightly sloping ground down by an ore-rich bog. The production zone is situated above the heap, and the test pit was placed in the slag heap facing the furnace zone*
 PHOTO: B. RUNDBERGET, MCH

age of the context. The wood was pine and the site was dated to AD 705–785 (Tr-3094, 1265 ± 25 BP).

Investigation of these three sites led to a surprising result. In the case of id 31853, the 14C date was as expected from the organization. The position on a low ridge was somewhat unusual, but not unparalleled. In the case of the other two sites, I had expected a date around AD 850–1000. Both 14C dates, however, fall as early as the eighth century, preceding the other dated sites. The 14C date of id 78190 should perhaps be placed a bit later because of the form of the charcoal sample used, and an adjusted date could perhaps lean towards AD 800. Until we have more 14C dates from this area, I would therefore suggest that the beginning of *jernvinna* with a tapping technology in Solør has to be taken back to no later than the middle of the eighth century. We have relatively few 14C dates, but there is no chronological break, and production continued into the thirteenth century. This information is important as here I discovered a phase of the Hedmark tradition which was hitherto unknown, and I shall return to its background in due course.

Kongsvinger and Eidskog

In the two southernmost administrative districts, our knowledge of iron production in the Viking Period and Middle Ages is very limited. In Kongsvinger, there are at present no sites that can with certainty be linked to the Hedmark

tradition. Several surveys have recently been carried out, for instance in Austmarka in the south of Kongsvinger,³⁰ but no trace of iron extraction was identified. Falck-Muus, however, mapped 13 sites in Kongsvinger, but none in Eidskog.

In Eidskog, six sites of the Hedmark type have been recorded later on. Five lie within a 500 m radius in an area that is extremely rich in bog ore (Fig. 4.11). The sites vary in size and structure. The identification of tapping slag testifies to a technology of the Hedmark type, but the organization is varied. One site is of a typical basic model with two parallel slag heaps. The others have more in common with the sites in Grue and Åsnes. Apart from Åmot Municipality and the newly investigated site in Åsnes, the only excavated site of the Hedmark type in Norway is the ironmaking site at Skotterud in Eidskog (id 29138) (see Ch. 2, Slag tapping shaft furnaces in Norway). The results from Martens's study show that this site conforms to the Hedmark type. This is also true of its 14C dates (AD 1020–1155).

The border areas have not been recorded to any great extent in either of these municipalities. But on the Swedish side of Kongsvinger, several sites have been recorded³¹ which, from their organization, are to be classified as belonging to the Hedmark tradition.

The absence of definite production sites in Kongsvinger may indicate that we are on the edge of the range of the tradition. This is corroborated by the paucity of known charcoal pits. Topographically and geologically, however, the landscape changes character, and it is only in the eastern parts of the district that iron extraction has any real foundation. This is confirmed by the fact that production extends on the Swedish side of the border. The recording of iron-making of the Hedmark tradition in Eidskog is predictable. The forest here extends westwards again, and the resource basis is greater than over much of Kongsvinger.

Hedemarken

Hedemarken lies on the eastern side of Lake Mjøsa and stretches eastwards to the watershed with the River Glomma. This corresponds to the municipalities of Stange, Løten, Ringsaker and Hamar. Knowledge of ironmaking in this area goes a long way back. The historian Gerhard Schøning,³² for instance, took

³⁰ Holm (2002) 27, 48.

³¹ Myrdal-Runebjer (1998).

³² Schøning (1775 [1980]) 32.

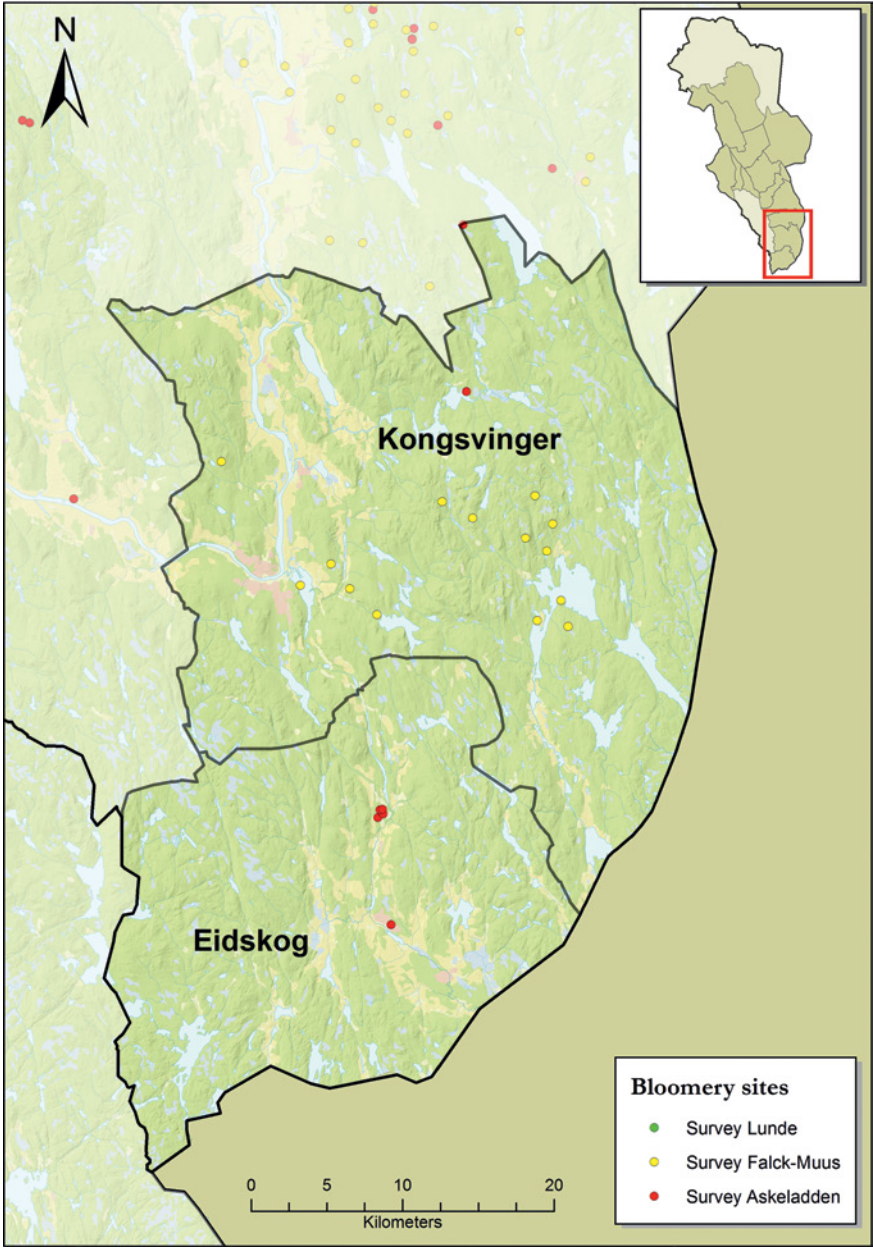


FIGURE 4.11 *The distribution of bloomery sites in Kongsvinger and Eidskog (after Askeladden) with sites referred to, also including the survey of Falck-Muus (1931)*
MAP: B. RUNDBERGET/M. SAMDAL, MCH

extensive iron production in Vang for granted as some of the land tax was calculated in iron.

In Hedemarken, extensive iron production has been demonstrated back to the Early Iron Age.³³ The picture is dominated, however, by medieval iron production, and the last phase of the Iron Age is very poorly represented in the evidence. In a study of the three communities of Løten, Vang and Ringsaker, Bårdseng³⁴ uses 79 known bloomery sites of the Late Iron Age and Middle Ages, which she divides into types according to variation in organization. A number of bloomery sites were recorded through the Åker Project and the Outlying Surveys,³⁵ and from the records in Askeladden at least 97 such sites can be securely associated with medieval *jernvinna*. Many of these have no records of their geometry, and are not visible in maps, so that the distribution map as in Figure 4.12 is incomplete. In the count, furthermore, the many records of Leif Bakke³⁶ in the outlying land of Ringsaker are not included. He has identified more than 40 sites with tapping slag. Eight of these are dated to the period AD 975–1280.

Bårdseng³⁷ has also dated a number of sites. With two exceptions with 14C dates to the seventh century, these all had a functioning period between AD 950 and 1300. She interprets the early 14C dates as representing a phase two centuries earlier than the main period of use, a view that I am doubtful of. In my view, a period of use followed by a break of several centuries before the same technology is reintroduced in exactly the same place is quite unlikely. On the contrary, I would suggest—as appears also to be the case in Solør—that production was continuous and that this ought to have been demonstrated in the relatively copious 14C-date evidence we have from Hedemarken. Alternative interpretations, such as that the site has an earlier and different technology, or that the evidence has been dated from old samples, or that it has come from a false context because of the method of excavation using test pits, might explain the situation. The breach in continuity and the absence of correspondence with the other evidence leads me to exclude the early 14C dates as evidence of the earliest phase of the tradition in this area (see Ch. 5).

Several charcoal pits have been investigated and dated to the period AD 1010–1285. On this evidence, iron extraction was very intensive in the upper wooded areas of Hedemarken. On the strength of the very comprehensive

33 Bakke (1997); Risbøl (1997); Bårdseng (1998); Engen (2002); Pilø (2002).

34 Bårdseng (1998) 39–54.

35 Pilø (1994); Bårdseng (1998) 7.

36 Bakke (1991), (1995), (1997).

37 Bårdseng (1998) 55–56.

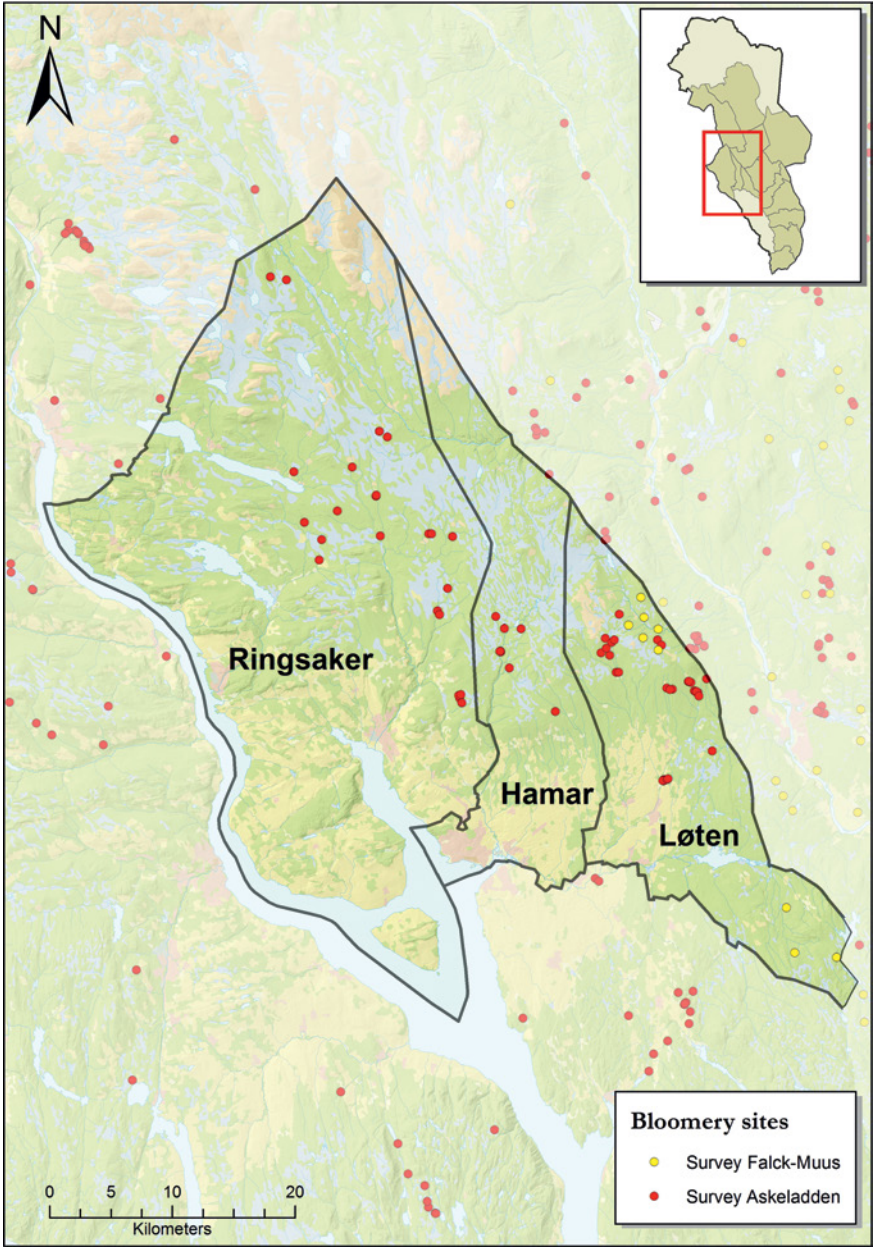


FIGURE 4.12 *The distribution of bloomery sites in Løten, Hamar and Ringsaker (after Askeladden)*
MAP: B. RUNDBERGET/M. SAMDAL, MCH

survey results from here, I consider that the level of production matches that of the rest of the area.

The sites of the Hedmark tradition extend practically up to the county boundary with Oppland and to Lillehammer Municipality. Only two sites have been identified in the far south of Lillehammer Municipality. Both of these are dated to the Early Iron Age. It thus appears that there was a boundary approximately at the dividing line between the counties.

The Delimitation of the Hedmark Tradition

The quantity of recorded evidence is huge, and it has, of course, not been possible to go into great detail in its presentation. That, however, is not of the greatest importance, as it is patterns and dimensions that I have focused upon. The extent of the tradition can best be read from the distribution of recorded sites and charcoal pits. The distribution map also helps us to suggest what the distribution may have been in areas that are poorly recorded, if at all. Altogether, there is a recurrent picture of a region that quite consistently appears to have been exploited in the same way, although there is clear evidence of reduced density at the edges of the region. At the same time, there are areas within the region which, because of their topographical and geological circumstances, have few, if any, traces of iron extraction.

On the whole, organization appears to have been highly uniform. As in the Gråfjell area, the bloomery sites are of the standard model (see Ch. 3, From concept to symmetrical organization). Several sites also have only one visible slag heap, especially in Hedemarken. There are also variants. As in the Gråfjell area, these are to be considered as consisting of several phases, where each new phase is defined by a shift in the production site. These sites comprise several basic and standard models.

The greatest divergence from the ordinary organization of the sites is found in Åsnes and Grue, where both the position and the organization of several sites differ from the standard model. This probably reflects an early period of use. The organization appears to be less systematic and the level of production is rather below average. At the same time, there are several similarities, such as the type of charcoal pits, the technology, the types of slag and the organization. Consequently, these sites are regarded as belonging to the same tradition. It may be most accurate to view these sites and their organization as an early phase of or a prototype of the Hedmark tradition. The basic form constitutes a foundation, but the production-line type of mass production with two furnaces and the use of common stockpiles of raw materials has not yet developed.

It is also important to note that some production sites in the southern region conform to the traditional norm with a single standard model, and it would thus appear that this region also followed the full development. Radiocarbon dates from the thirteenth century support this.

The evidence from the whole region displays such clear common features with the Gråfjell area that this has to be understood as a single area of tradition: the Hedmark tradition. With this, I have opened a discussion of the delimitation of the tradition. It is not possible to draw sharp boundaries from the available evidence. The dividing lines, however, are very clear. In discussing boundaries, it is also crucial to remember that these are not static (see Ch. 7, *The written sources*). A dividing line may be partly determined by topographical elements, while in other respects it may be fluid and unclear. The boundary may also change in character over time. Here the outer boundary is established, and in a later chapter the delimitation will be discussed in relation to the topographical and socio-political contexts of the Viking Period and Middle Ages.

In the north, there is evidence of bloomeries according to the Hedmark tradition some kilometres north of the centre Koppang. The most northerly known production sites in Rendalen are further north still. Further north than that no sites of the Hedmark type have yet been recorded. Nor have charcoal pits been recorded to any great extent, apart from those that surround the bloomery sites. From the sites known in Rendalen it has, however, to be accepted that the tradition was quite familiar in this district. For this reason, I classify the southern part of Rendalen as part of this tradition, even though it was manifestly a marginal zone.

To the north-west of Stor-Elvdal, the picture is easier to interpret, as the recorded evidence from Atndalen and Sollia implies that iron extraction had its origins in Gudbrandsdalen. West of the River Glomma and Koppang, the landscape is virtually void of finds. Only three sites have been found. A challenge to interpretation is the site that is situated far down in the valley of Imsdalen. From the type of slag heaps, the flowing slag and the round charcoal pits, this site has clear parallels in Gudbrandsdalen. However, the two other sites correspond to the Hedmark tradition. Imsdalen and its subvalleys, then, seem to be a part of the Hedmark tradition, while the remaining area west of Glomma seems not to be utilized. In the area east of Glomma, on the other hand, there is a great density of sites of the Hedmark tradition and of square charcoal pits. This clear difference, with an absence of finds in the west and a wealth of finds in the east implies that there was a boundary that ran practically parallel with Glomma. The picture further north in Atndalen and the site in Imsdalen also indicate that the areas west of the river may

have westerly connections, while the region east of Glomma is classified as pertaining to the Hedmark tradition.

This pattern holds southwards to Åmot. Here the distribution changes, and sites of the Hedmark tradition occur west of the River Glomma watercourse, across Hedmarksvidda and into the forests of Ringsaker and Hamar. Production does not extend down into the settled lowland districts but is located in the higher forest areas. The lower forest areas are also perforated with charcoal pits, albeit here without accompanying bloomery sites. These charcoal pits are to be associated with smithing activity at the farms and in the trading site of Hamar where great concentrations of forging slag have been found.³⁸ This distribution continues into Løten. Bloomeries with associated charcoal pits are found far into the forests, but the outlying land close to the settled districts was used for making charcoal for blacksmithing. Ironmaking in Løten was concentrated in the northern and eastern areas bordering on Elverum.

The boundary then turns eastwards again towards the River Glomma and, south of Åsnes, the Hedmark type is once more recorded only to the east of the river. This pattern continues south to Kongsvinger and into Eidskog. From the southern part of Grue, the density is markedly lower, and the intensity was less in the southernmost area, even though there were probably many ironmaking sites here too.

This interpretation is made by including bloomery sites across the Swedish border. Ten sites with associated charcoal pits have been recorded in the areas of outlying land in the southern part of Torsby Municipality in Värmland³⁹ (Fig. 4.13). From the descriptions of type and organization, the production can be classified as belonging to the Hedmark tradition. At four sites, Östmark 421:1, Östmark 190:1, Östmark 194:1 and Lekvatnet 174:1, trial trenches were dug and the sites are dated to AD 1008–1155 (975±70 BP), AD 917–1102 (1040±60 BP), AD 899–1092 (1055±70 BP) and AD 1040–1190 (925±70 BP).⁴⁰ The period of use corresponds closely with the dated production sites in Eidskog, Grue and Åsnes, but it is striking that the activity ended in the second half of the twelfth century. The sites are an important piece in the distributional jigsaw as they show that the tradition extended unbroken to and into Eidskog and that there is no break in Kongsvinger. In Arvika Municipality south of Eidskog, by contrast, not one bloomery site has been recorded. The survey work, however, has not been so extensive in Arvika; nonetheless, the picture appears unambiguous from

38 Sæther (1989); Pedersen (2000).

39 Myrdal-Runebjer (1998) 4, (1999).

40 Myrdal-Runebjer (1999).

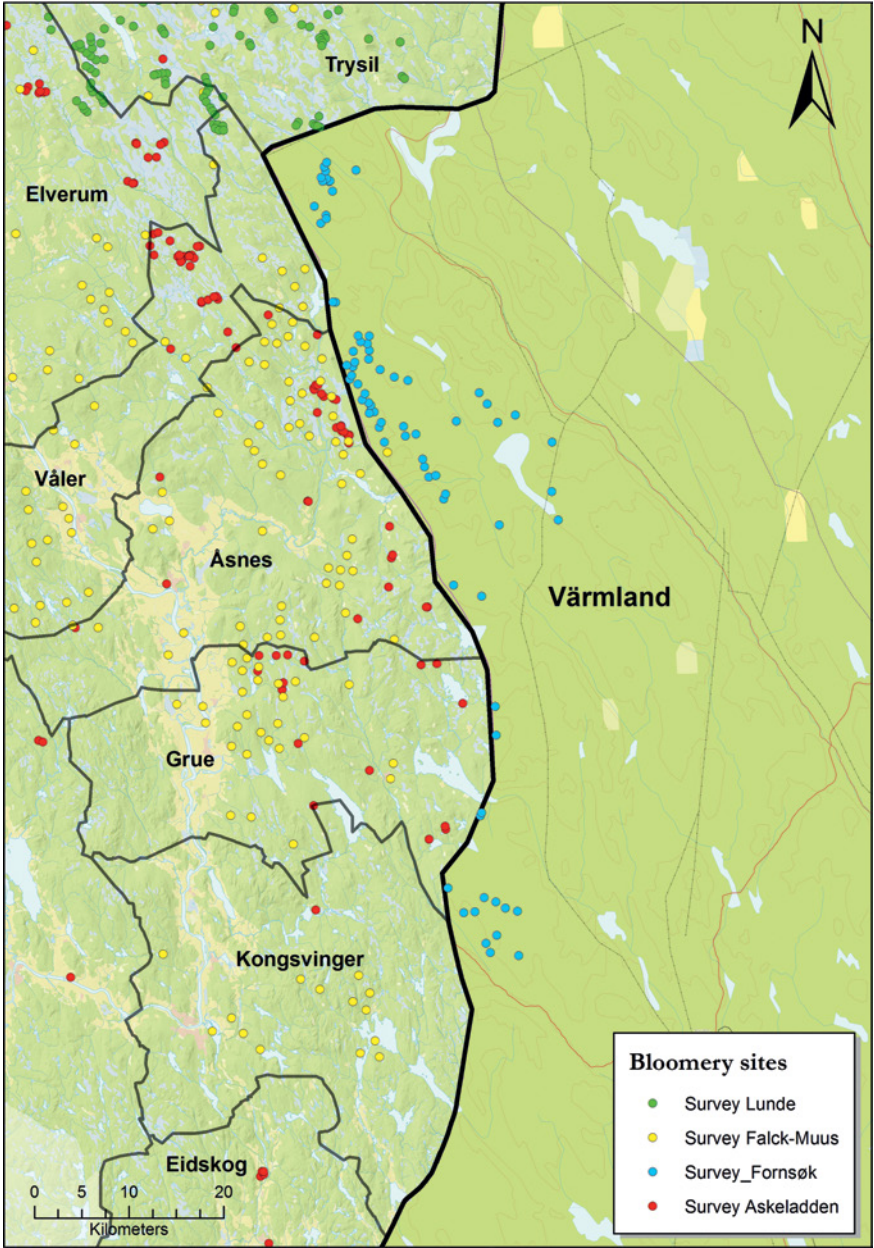


FIGURE 4.13 *The distribution of bloomery sites in Värmland (after Fornsök)*
MAP: B. RUNDBERGET/M. SAMDAL, MCH

the absence of finds, and I therefore define Eidskog as the southernmost area of this tradition.

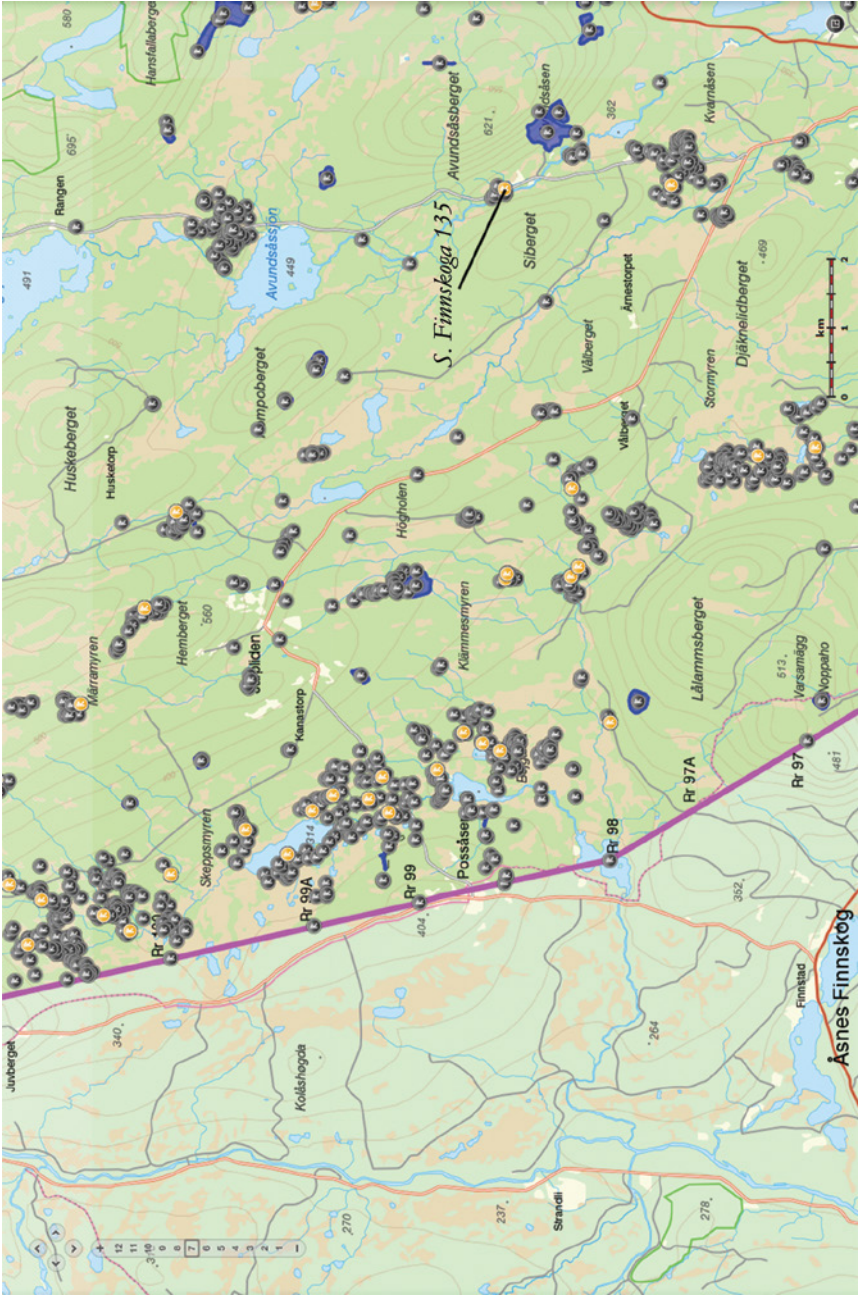
Further to the north in Torsby, east of Grue, Åsnes and Våler, there are also a number of bloomery sites. These are concentrated mostly across the border, 3–4 km into Sweden (Fig. 4.14). The types of slag, the organization of the iron-making sites, and the organization of the charcoal pits show that they pertain to the Hedmark tradition. Altogether, around 90 bloomeries have been recorded in this area, some 15 finds of slag, and fully a thousand charcoal pits. Svensson⁴¹ has investigated and dated several sites. She has divided them into three groups, of which the bloomery sites with no visible furnaces but with charcoal pits surrounding the site (group 1) are of most interest here. The other groups involve later stone-walled furnaces with parallels to the Evenstad type. The distribution attracts attention, as sites of group 1 are located west of the River Klarälv, while the other groups primarily occur east of this river. Altogether, Svensson counts 62 bloomery sites of group 1, 18 of which are dated. One site has ¹⁴C dates from the fifth or sixth century. The remainder are dated within the period AD 700–1240; only one site, however, has a terminal date after 1180. The main concentration is in the period AD 850–1180.⁴² Twelve charcoal pits have also been dated, and the picture is the same. Two production sites have been excavated, Södra Finnskoga 135 (Fig. 4.14) and Norra Finnskoga 224. The former consisted of two furnaces and two slag heaps (three, as one of the furnaces had two small mounds of slag). One charcoal pit lay within the production zone beneath a slag heap. This slag heap is associated with an early phase, while the other two are both later and contemporary. The furnaces lay one above the other with stockpiles of raw materials between them but somewhat to one side of the furnace zone. Two stores of charcoal indicate a change in organization, although a single stock of ore implies contemporary or continuous work. The ¹⁴C dates for the site support this interpretation and Svensson⁴³ has given the period of use as c. AD 900–1150. The organization is congruent with the standard form for the Hedmark tradition.

The site Norra Finnskoga 224 is of the same type, consisting of three furnaces and three slag heaps. Two of the furnaces and the slag heaps lie directly beside one another and the third furnace, with its associated waste heap, is placed immediately alongside. The stockpiles of raw materials are situated between the furnace zones and the site comprises one standard model with one basic model. The stores of raw material, however, remained the same throughout the sequence of production. Radiocarbon dates show that the site

41 Svensson (1998) 83–100.

42 Svensson (1998) 87–89.

43 Svensson (1998) 92.



Extract from Fornsök showing the distribution and organization of iron extraction in the north of Torsby east of Asnes-Finnskog. As in Norway, the charcoal pits surround the bloomery sites. On the Norwegian side, spot recordings have been made (see Fig. 4.17: Askeladden). Together with Falck-Muus's mapping, these reveal an equally great density here. The excavated site, S. Finnskoga 135, is marked on the map

FIGURE 4.14

of the basic model is earlier and that the furnaces of the standard model are both later and contemporary. Svensson judges the period AD 1000–1140 to be the probable dates of use.

Svensson⁴⁴ concludes that the sites of group 1 came into being in the Late Iron Age and were at their peak in the Viking Period and Middle Ages. She characterizes this tradition as being found west of the River Klarälv, while production on the eastern side is primarily of a later period. The furnaces at both sites are of the free-standing slag-tapping shaft type with a pit underneath. This description is congruent with what the studies in the Gråfjell area have revealed, and I consider it a fact that southern Hedmark and north-western Värmland shared the same tradition. This is also emphasized by Svensson⁴⁵ in that she regards the evidence from Rødsmoen as equivalent in form.

From the database Fornsök, I have classified 76 bloomery sites in Torsby as of the Hedmark tradition (see Fig. 4.14). The sites lie in a north–south belt from the border up to 15 km within Sweden. It is difficult to ascertain any clear topographical dividing line to the tradition in the south of Torsby. However, from Syssleback northwards, the River Klarälv appears to form a clear boundary line. South of Syssleback, sites of the Hedmark type are known only right alongside the national border. The distribution pattern as we have it at present thus indicates that the tradition was partly delimited by the Klarälv but that its boundary moves back towards Norway in the south.

This distribution is clearly related to that in Trysil, with ironmaking west of the Trysil River. Medieval *jernvinna* is found profusely on this side yet is completely absent to the east. To the north in Trysil, the density reduces west of the river as well, and in the far north of the municipality only one charcoal pit has been recorded. Little survey work has been undertaken in this part of Hedmark, and no certain boundary can be defined. The basis of the line that I would draw is the northernmost sites and charcoal pits in Trysil together with the sites by Holla in the south of Rendalen. From their position, I consider it logical to locate a boundary line along the Trysil River all the way north to Rendalen.

This gives us the extent of the Hedmark tradition (Fig. 4.15). The region has an area of around 11,400 m³, the greatest part of which is forest land that is very well suited for ironmaking. The region is complex, and comprises areas of both high and low density. I shall pursue the questions of both distribution and intensity further in due course, but before that it is necessary to introduce two further, crucial factors—the regional chronology of the Hedmark tradition and the level of iron extraction both spatially and chronologically.

44 Svensson (1998) 98–101.

45 Svensson (1998) 85.

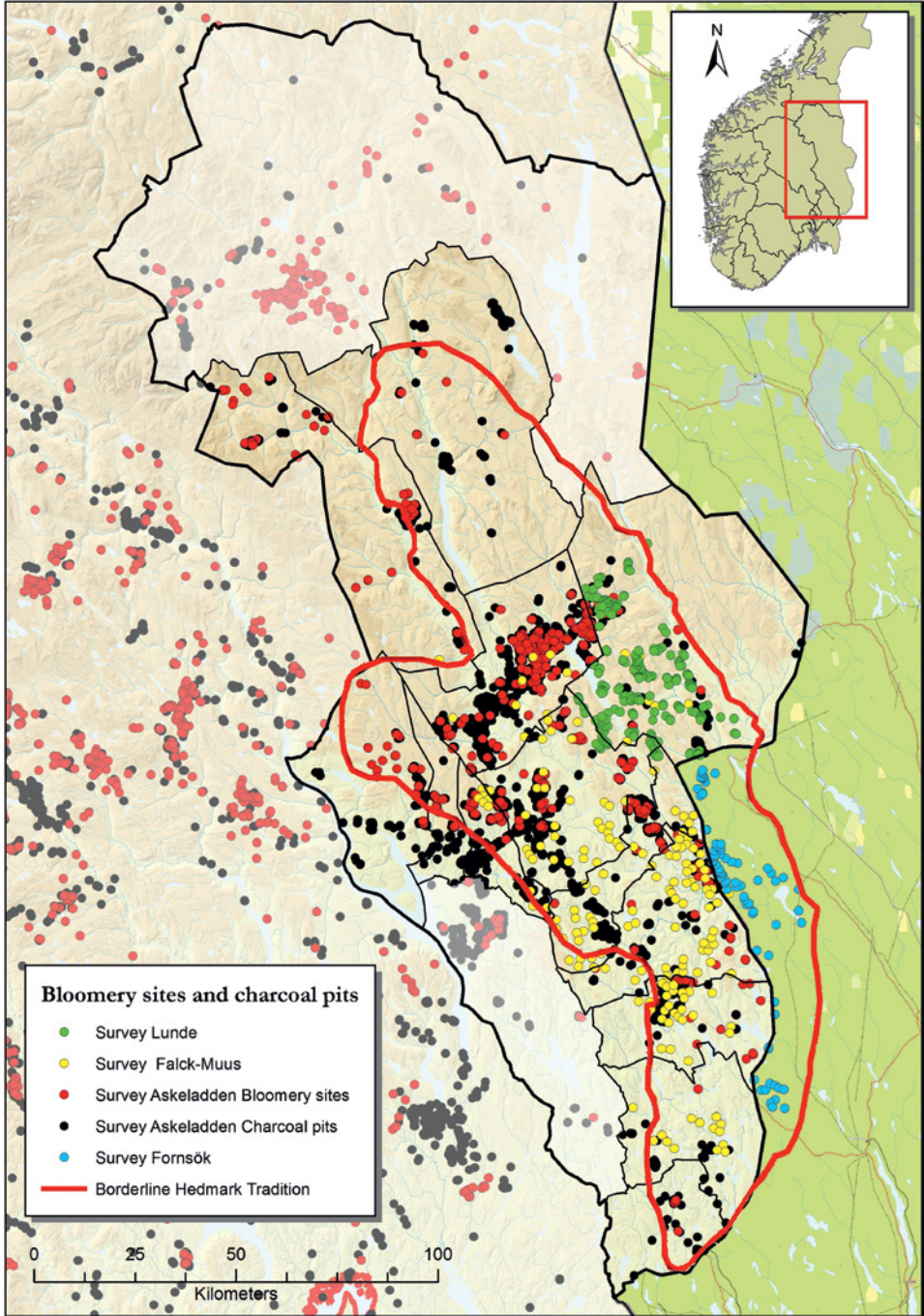


FIGURE 4.15 *The extent of the Hedmark tradition, with borders marked. Charcoal pits are also shown on the map. These largely follow the distribution of the bloomery sites, but as both smithing charcoal pits and more recent charcoal kilns are included, there are some discrepancies. The border cannot be considered static and fixed but rather dynamic and changing*
MAP: B. RUNDBERGET/M. SAMDAL, MCH

The Dating of the Hedmark Tradition

In the Gråfjell Project, great importance has been attached to establishing the chronology of *jernvinna*. This has been based upon the interpretation of radiocarbon dates of charcoal, supplemented by dendrochronological dates of fully or partially preserved logs.¹ In this chapter the topic is discussed in more depth by introducing statistical probability calculations in order to narrow the date range of individual bloomery sites in the Gråfjell area. I shall also look at variation in the activity over time and use all of the available dates to try to generate a chronological framework for the whole study area.

Introduction

The dating of historical events by means of the radiocarbon method is a useful tool for relative dating.² There is a continuous development of the analytical evidence, and the calibration curves are updated at regular intervals, leading to a considerable increase in precision. It is consequently difficult to compare evidence dated nowadays with its equivalent from 30–40 years ago. In Norway, recent years have seen an important advance in the development of ¹⁴C dates as what are referred to as ‘conventional’ methods (i.e. the measurement of radioactive decay in gas) are no longer used. The evidence that is used here has, however, largely been dated using these conventional methods. The main reason for this was the constraints of time and cost, while the results were also considered good enough to create chronologies of the sequences of activity. With hindsight, one may disagree with this conclusion, as in the process of writing up I have recognized that it might have been more appropriate to reduce the number of ¹⁴C dates and instead to have gone for more accelerator mass spectrometry (AMS) dates, which more readily give lower ranges in years $\pm$ BP (Fig. 5.1).³ This would hold for research into ironworking generally. The ¹⁴C dates of charcoal pits produce the expected result in 95% of cases.

1 Rundberget (2007) 309–321.

2 E.g. Michels (1973); Aitken (1990); Dincauze (2000).

3 Conventional radiocarbon dating is not intrinsically less precise than AMS: it depends on the size of the sample and, in this case in particular, the length of time we are prepared to pay for, or have the opportunity to leave it in the counter.

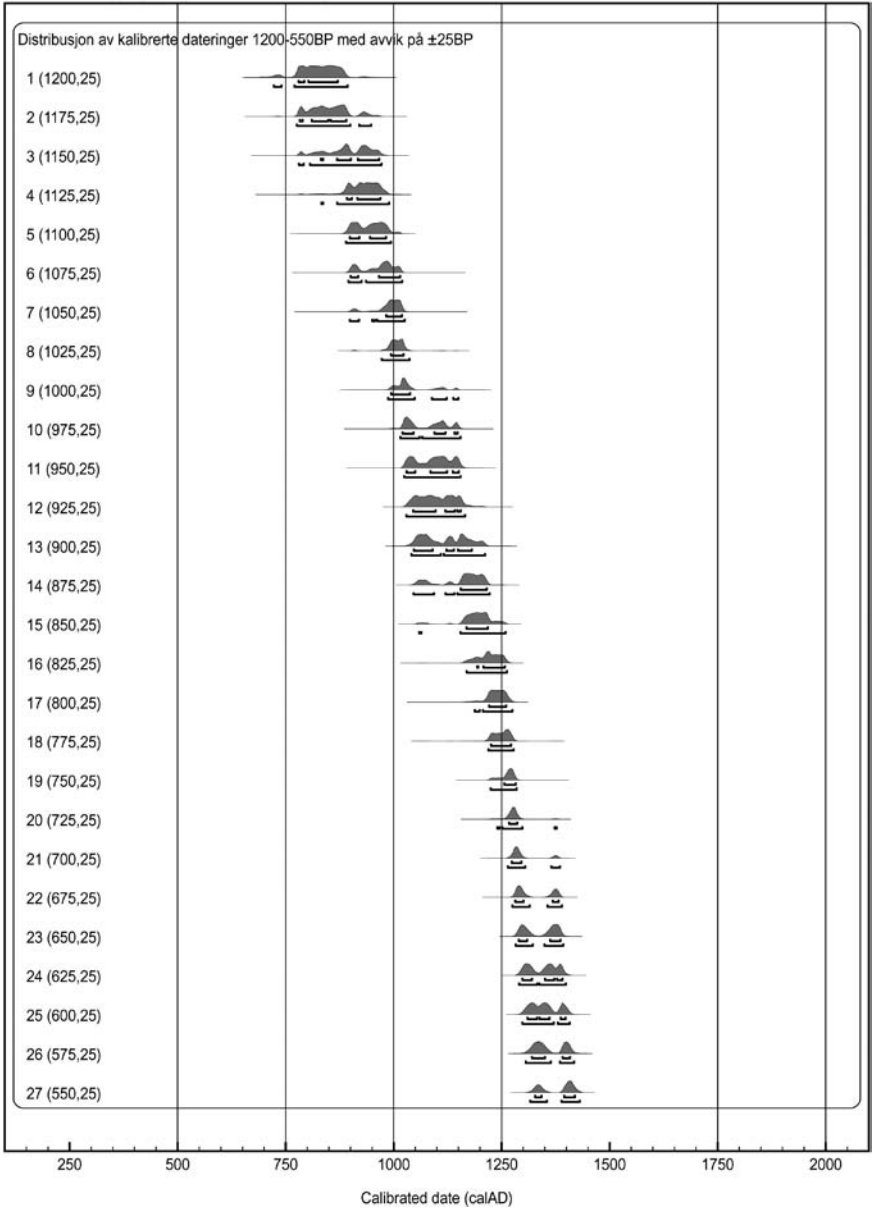


FIGURE 5.1 *The distribution of calibrated dates presented in 25-year intervals across the period 1200–550 BP and with ranges of ± 25 BP and ± 75 BP (opposite side). The first column represents a normal accelerator dating, while the last column represents a typical conventional dating. One is given a clear impression of the advantage of accelerator datings in chronological approaches*

OXCAL V4.1.4 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER ET AL (2009)

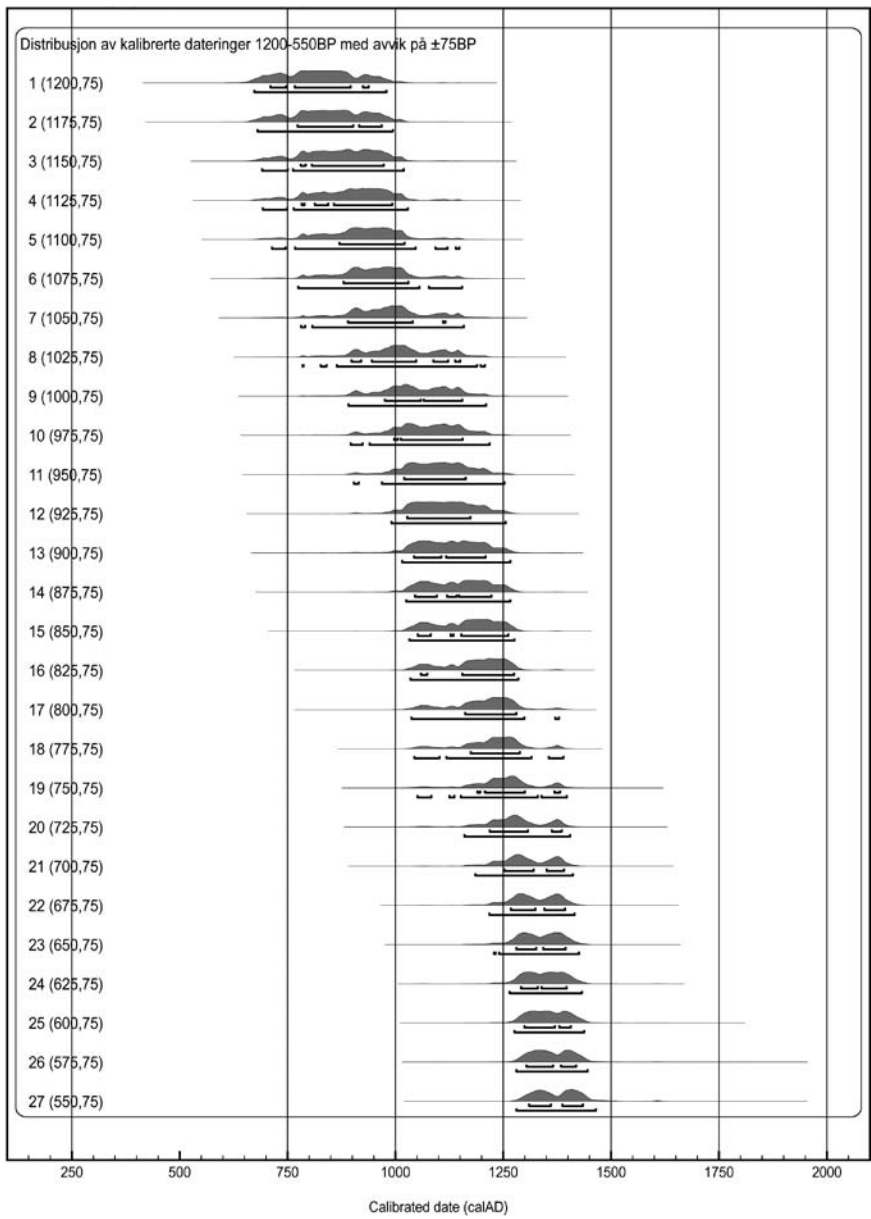


FIGURE 5.1 (Cont.)

This means that the dates fall within the Viking Period/earlier Middle Ages, but cover such a wide span that it is difficult to proceed to reliable and precise chronological interpretations. A wider use of AMS dates would produce results that might better reflect the span of the activity in question.

We must not paint a black picture of the state of affairs, however. There are some very useful results for the chronology of *jernvinna* considered in a wide geographical perspective, such as, for instance, the mapping of *jernvinna* activity in south-eastern Norway.⁴ In these circumstances, the level of precision is not necessarily so essential when several regions with greater or lesser chronological variations in the activity are included in the analysis. It is a greater challenge when just one region or area is studied and the objective is to map out details of the activity, such as its date of introduction and cessation, possible phases at production sites, or the relocation of activity within the region in question.

The Bayesian Approach

Answering questions of this type was an aim in the Gråfjell area, and the results we have are reasonably reliable even if rather imprecise. In order to address the question better and to minimize the range of probability as far as possible, I make use of the *Bayesian approach*, through which statistical calculations of probability provide a firmer grip in the interpretation of the activities in time and space.

Bayes's method is an instrument for dealing with uncertainties and formalizing the relationship between a belief and a conclusion. Its essence lies in combining an understanding of a problem with data that relates to the problem in order to produce an inference about it.⁵ The method is model-based. This means that, starting from the known and unknown parameters, it can only *model* probable statistical relationships. The method has been developed from Thomas Bayes's theorem, the starting point of which is that if one has experience or knowledge of a topic, and then obtains new information about that topic, one will be able to develop a new understanding of it. The theorem comprises three parameters. *Prior beliefs* are our starting information and *Standardized likelihood* is the new information (data). The combination of

4 Larsen (2004); Larsen and Rundberget (2009).

5 Buck et al., (1996) 2.

these, the extant and the new, is therefore *Posterior beliefs*.⁶ In this context one can say that an existing ¹⁴C date has limited scope for interpretation because of its high uncertainty. By including and analysing new data, the uncertainty is reduced and the interpretations can be more precise.

A core feature of Bayes's theorem is that it is cyclical and based upon the hermeneutic principle. Today's *Posterior beliefs* are tomorrow's *Prior beliefs* as new information is continuously being added. The result is that *Posterior beliefs* are the product of *Standardized likelihood* multiplied by *Prior beliefs*.⁷

This method will produce quantitative calculations for events (*Posterior beliefs*) by combining a scientifically known age, e.g. a radiocarbon date (*Standardized likelihood*) with a relatively known age, e.g. stratigraphical relationships from which the dated material has been taken (*Prior beliefs*). *Posterior beliefs* is thus a term for a probable distribution. The results are not absolute, but can be reassessed by introducing new data (e.g. new dates) or by modelling known data using new perspectives (e.g. new calibrations).

In order to perform calculations using mathematical data of this kind, *Markov Chain Monte Carlo Simulation* (MCMC), named after Andrei Markov, is used. This can be characterized in terms of a system that can subsist in various states and which is varied randomly at different steps. In practice, this means that the probable distribution within the system in the next step, and in all future steps, is only dependent upon the immediate state, and not on earlier steps in the system. How this method is applied in practice in an archaeological context is well illustrated by, *inter alia*, Buck et al., and Whittle et al.⁸ Several calibration programmes with which this method can be used have been produced. In my study, OxCal v4.1.4 and OxCal v4.1.7 are used.

The application of Bayes's theorem within OxCal is explained by Bronk Ramsey.⁹ We start from two premises, as *Prior beliefs* which are both accepted for modelling. The first can be described as *informative prior beliefs*, which is some specific statement of the known relative age of radiocarbon dates. This defines a precondition, that the samples are associated with good archaeological contexts. What is critical is that the sample one wishes to date has the same age as the context one wishes to date. The other premise is an assumption concerning the mathematical distribution of the events we are trying to date. All radiocarbon dates have a probability that is narrower or wider and expressed

6 Lindley (1985) 98–100; Buck et al., (1996) 16–19; Bayliss et al., (2007) 4; Whittle et al., (2011) 21–34.

7 E.g. Buck et al., (1996) 20–21; Whittle et al., (2011) 21, Fig. 2.5.

8 Buck et al., (1996); Whittle et al., (2011).

9 Bronk Ramsey (2009a), (2009b).

as values $\pm nBP$. In the situation of having a number of dated contexts, we are very likely to obtain a range that extends outside of the phase we wish to date. This margin of error is indeterminate and is referred to as *uninformative prior beliefs*. In order to correct for this, a parameter is employed whereby it is assumed that the samples included in the analysis have a uniform distribution; in other words, that they should belong together within a given period of time.

When the model is produced, a calculation of the probable range of each individual sample is included. These are then tested using the MCMC method, with each distribution used to build up a set of solutions that agrees with the structure of the model. The result is that *Posterior beliefs* are produced, within which each sample analysed is constrained to cover only some of its own calibrated date range. Without referring to the individual dates, the model is also able to suggest a more precise start date and end date for an event or an activity. In more complex situations, the extent of phases and the relationships between several phases can also be defined.

Two elements that are fundamental to an interpretation are produced by this statistical method. Firstly, there is a log which shows the agreement (*index of agreement*, designated A), related to the standardized probability of the sample produced by calibrated ^{14}C dates. *Posterior beliefs* are required to have an A score of 60 or more. If the index of agreement is lower, then reinterpretation is required. This could happen, for instance, if one or more of the dates has a wide range, and where most of the distribution fall outside the most probable range. A second possibility is that *informative* or *uninformative prior beliefs* in relation to one or more samples are incorrect (e.g. from the wrong context or from sampling older material). In analyses where several parameters are included within the same analysis, for instance if one has both radiocarbon and dendrochronological dates, a combined index of agreement will be generated (*Acombined*) which shows the relationship between them. From these an overall index is calculated (*Aoverall*). This value measures the agreement between the *Prior beliefs* and *Standardized likelihood* for the individual samples brought together. Finally, there is an index of agreement for the model as a whole (*Amodel*). This can also include separate phases and, if desired, a calculation of *Posterior beliefs* for the start (Boundary S) and the end (Boundary E). If this value falls below 60% then all of the parameters in the model have to be reviewed.¹⁰

The second element is a function of the model and is called 'convergence'. This measures the efficiency of the MCMC analyses through assessment of the agreement of the analyses that are undertaken. A good level of agreement produces reliable and stable *Posterior beliefs*. If the convergence is below 95%

10 Bronk Ramsey (1995); Bayliss et al., (2007).

then the solution is unreliable and one ought to review all of the parameters to find out why.

This method yields good grounds for interpretation with samples with wide probability ranges in terms of large $\pm$ BP values. The method is particularly useful with a mass of evidence. In the research into *jernvinna*, where ^{14}C dates have been fundamental to the establishment of chronologies, this method is therefore a very valuable instrument.

The Summing of Radiocarbon Dates

Using OxCal, it is possible to use a command to calculate the sum of a series of radiocarbon dates. This is done by combining the probability ranges of all the samples. This involves a normalization, with the probability of all samples set equally to 1. As a result of this, a small proportion of the outer range will become invisible. The model has been called *floruit*, referring to a period of time in which the central two quartiles (50%) of some production or activity is carried out (or 'flourishes').¹¹ The method is generally accepted as useful in archaeology, although it has been criticized, not only for being unsubtle but also for producing simply incorrect results.¹² The key problem is that the event or activity that is to be dated will be represented as continuing over a longer period than was actually the case. Inaccuracy increases, the larger the number of dates. An example of what this can produce will be considered later, after a review of the material for analysis.

Wood Species and the Dating of the Hedmark Tradition

Dating has been a central question in research on *jernvinna*, but it was only when ^{14}C dating was introduced that it became possible to undertake direct dating (see Ch. 2, Methods of production in chronological terms). Before this, finds of slag from other contexts with typological sequences formed the chronological framework.¹³ Nowadays, ^{14}C dating is a standard procedure when bloomery ironmaking is to be dated in Norway. This differs from, for instance, Denmark, where only 73 radiocarbon dates have been produced.¹⁴

¹¹ Ottaway (1973); Aitchison et al., (1991) 108.

¹² Buck et al., (1996) 6–7; Bayliss et al., (2007) 9–11; Bronk Ramsey (2009a) 339.

¹³ E.g. Falck-Muus (1927); Hauge (1946).

¹⁴ Pers. comm. Olfert Voss, 30 January 2011.

Since Martens's pioneering work at Møsstrond,¹⁵ where a desire for the wide use of ¹⁴C dates was the basis for the research, there are now more than 3,000 ¹⁴C dates from southern Norway as a whole.¹⁶ An objective of mass dating is to produce a more nuanced chronology, allowing, for instance, the study of possible regional or local variations in the pattern of activity, or the examination of activity at individual sites. Central questions may be the period of use (beginning/end), phases of use, breaks or continuity, and the organization compared with what is understood to be associated charcoal pits or roasting sites.

¹⁴C dates now provide a framework for the chronology of bloomery iron-making in Hedmark. Under the Rødsmo and Gråfjell Projects, all excavated bloomery sites have been dated, in addition to a large proportion of the charcoal pits and roasting sites.¹⁷ There are also a number of ¹⁴C dates from smaller-scale surveys and investigations. I know of 549 radiocarbon dates altogether¹⁸ that I take to relate to the Hedmark tradition (Tab. 5.1). Outside of the Gråfjell area, from other sites in the study area, ¹⁴C dates have been obtained from 66 bloomery sites (44 in Norway and 22 in Sweden) and 107 charcoal pits (several charcoal pits have two or more radiocarbon dates). There are ¹⁴C dates from all of the administrative districts in which this tradition has been recognized. In some municipalities, a large number of ¹⁴C dates are available, while others only have one or two. In Elverum, for instance, 52 charcoal pits have been investigated and dated, primarily because of either large- or small-scale development cases. On the other hand, Trysil has only one charcoal pit that has been investigated and dated. In Appendices IIa–c, there is a complete list of all of the ¹⁴C dates and their geographical distribution. In this study, the evidence from the Gråfjell area forms the principal basis for interpretation. From the quantity of the evidence and the conclusion already drawn concerning the homogeneity of the tradition, I regard these results as representative of the region as a whole. The results from the Gråfjell area are consequently used as parameters for other regions too.

Wood Species Determinations

One aspect of the ¹⁴C dates has been the identification of wood species. These are important in several ways, especially in connection with the issues of the

15 Martens (1988) 5.

16 Larsen (2009) 180, with refs; Rundberget (2010) 37.

17 Narmo (1997); Rundberget (2007) 309–322.

18 As at 1 August 2012; Appendix IIa–c.

TABLE 5.1 *Overview of the radiocarbon dates obtained for the Hedmark tradition per county*

¹⁴C-datings of the Hedmark Tradition				
<i>Kommune</i>	<i>Bloomery site</i>	<i>Charcoal pit</i>	<i>Roasting place</i>	<i>Total</i>
Stor-Elvdal	1	3	—	4
Rendalen	1	—	—	1
Åmot	—	9	—	9
- Rødsmoen	19 (6 sites)	12	—	31
- Gråfjell	192 (42 sites)	134	10	336
Trysil	1	2	—	3
Våler	1	20	—	21
Elverum	1	53	—	54
Løten	4	5	1	10
Ringsaker	7	8	—	15
Hamar	17	4	—	21
Åsnes	3	4	—	7
Grue	1	1	—	2
Eidsskog	1	—	—	1
Torsby	22	12	—	34
<i>Total</i>	<i>271</i>	<i>267</i>	<i>11</i>	<i>549</i>

old wood effect and time-width,¹⁹ and the use of types of timber. There may be great differences in age between pine, spruce and birch, with consequences for the interpretation of the results. A ¹⁴C date that is out of line with other ¹⁴C dates of the same context may be due to the time-width of pine or spruce. If the ¹⁴C date has been taken from birch then other factors are most probably responsible. If one has a collection of samples which includes different species, it makes best sense to select birch rather than pine. The type of wood also reveals much about the use of resources, what types of wood were preferred, and what types of wood were accessible. This is thus important information for both natural and cultural history.²⁰

Studies of wood species also show that the exploitation of this resource varied both chronologically and geographically. A general trend is for production in the Early Iron Age to have been based almost entirely on pine, with birch being brought into use at the transition to the Late Iron Age and the introduction

19 <http://www.radiocarbon.com/old-wood-effect.htm>.

20 Loftsgarden et al., (2013).

of the tapping technology.²¹ There are several reasons for this. The ironmaking sites of the Early Iron Age are mostly lower in the landscape than those of the Viking Period and Middle Ages. Their position is thus linked to conifer woodland. In the earliest period in which iron was being made, spruce had not yet been introduced to Norway. Spruce migrated in from the east, and into Hedmark, and gradually expanded its range north and south.²² Pollen analyses from several sites in Østerdalen show signs of spruce around the beginning of the Christian Era, but in many places it was several centuries before it was a major part of the range of vegetation.²³

Pine was quite naturally used in the earliest bloomery ironmaking. But even after the spruce woodlands had become common, pine was still the first choice. In the Early Iron Age, it was probably commonest to char the wood in the furnace itself. Even though spruce was established in several areas of iron production, pine was still the preferred wood. It is believed, in consequence, that the massive level of iron production in Trøndelag in the Roman Iron Age led to deforestation in the case of pine and the rapid establishment of spruce.²⁴ This deforestation does not, however, appear to have had a great impact on the choice of timber. There is no clear sign that other types started to be used to any great degree.

Along with the technological shift in which the slag tapping technology became a standard procedure, there was also a shift in the exploitation of resources. Iron production was moved away from the environs of the farms and up into the valleys and low mountain areas. Here, birch predominated, and it would thus have been logical for this type of wood to have been the commonest form used in the Viking Period and Middle Ages. However, the picture can be rather more complicated than that. At Dokkfløy in Gausdal there was no abrupt transition, and pine continued to be used in the first phase of the slag tapping technique. This is understood to be related to the fact that pine was the preferred type of wood, and that birch was brought into use when that was all used up.²⁵

The situation in Hedmark was different. Irrespective of period, conifers are used for ironmaking here. This is explicable in natural terms, as the large iron-producing areas of Hedmark are lower in the terrain, around 350–750 m ASL, in a landscape dominated by the Taiga. The analyses of wood species in the Gråfjell area reflect this nicely. Altogether, 453 samples of charcoal have been

21 Larsen (1991); Espelund (2005); Larsen and Rundberget (2009) 41–42.

22 Hafsten et al., (1979) 171.

23 Høeg (1996) 138.

24 Solem (1996) 96.

25 Larsen (1991); Narmo (1996a).

identified (Tab. 5.2). Of this, 65% is pine, 20% spruce, and 13% a combination of these species. There are 10 samples which contain birch, or willow and aspen, all in combination with either pine or spruce. The statistics show quite conclusively that types of wood other than pine or spruce were not used for ironmaking. Of the 10 samples, it was only in one charcoal pit that birch appeared together with pine. The deciduous trees are otherwise only represented in slag heaps, in one charcoal stockpile, and in stockpiles of ore. From the context, I infer that these are connected with the clearance of the area or some other use of fire, such as cooking, kindling, etc.

Pine predominates, and would appear to have been preferred over spruce. All the same, the amount of spruce is high enough that it must have had properties that were satisfactory for iron extraction. The presence of both species in charcoal pits with only one certain phase of use also shows that both were used together. The quantitative uncertainties here can be large, as the samples are by preference taken from a small context, and often only a single piece of charcoal is taken. The number of charcoal pits with mixed material is therefore probably higher.

The relative preponderance of the species should nonetheless be regarded as representative. The geographical distribution of the samples is thus an important detail, and in this respect clear topographical and vegetational differences appear. In the south, where pine moors are predominant, pine was used in the charcoal pits without exception. The landscape rises gradually towards the north, and simultaneously becomes hillier and wetter. In the material under analysis this is reflected by the replacement of pine by spruce. This is particularly the case in the north-west, in an area where spruce is now predominant. The exploitation of raw materials appears logical in this light. In the north-east, on the other hand, only pine is found in the evidence. Nowadays the vegetation consists of much mixed woodland and the material analysed

TABLE 5.2 *Wood-species analyses undertaken during the ironmaking investigations in the Gråfjell area per year*

Species/Year	2003	2004	2005	Total
<i>Pinus</i>	57 (45%)	142 (74%)	92 (71%)	291 (65%)
<i>Picea</i>	37 (29%)	29 (15%)	24 (19%)	90 (20%)
<i>Picea/Pinus</i>	31 (24%)	17 (9%)	11 (8%)	59 (13%)
<i>Other</i>	3 (2%)	5 (2%)	2 (2%)	10 (2%)
<i>Total</i>	128	193	129	450

implies that pine was preferred. The north-eastern area consists of relatively few and small sites in comparison with the areas of greatest intensity. It could therefore be that the exploitation of resources was light enough that there was no need to bring spruce into use. The use of timber in the Gråfjell area would thus appear to have been determined by two factors: access and demand, albeit without this having any decisive impact on the finished product. The picture is the same for the rest of the evidence of the Hedmark tradition. Pine predominates, but the presence of spruce is at a level that shows that both species were used across the whole region.

Large quantities of timber were also used for roasting bog ore. Of the 10 roasting fires that from their 14C dates can be associated with medieval *jernvinna*, spruce was used in 6 and pine in 4 cases. The number is too low for conclusions to be drawn, but it is not improbable that spruce was preferred for this activity because the ore-rich bogs usually lie in environments where spruce forest is predominant. However, it is also possible to see an organized practice whereby spruce was used for roasting and pine for charcoal burning, especially in areas where there was limited access to timber.

Annual Growth Ring Counts and Dendrochronology

For the first time in Norway, as far as studies of iron extraction go, dendrochronological dating was widely applied in the Gråfjell Project. There are three principal problems affecting dendro-analyses of charcoal: the structure of the annual growth rings, their number, and the condition of the samples. For the Gråfjell Project, this problem emerges in two different situations, as the samples come from two contexts; charcoal pits, and staves from the lining in the isolation pits. The logs from the charcoal pits often lack the outer rings because they have peeled off. The samples of timber from the isolation pits, conversely, lack both the inner and outer rings because the staves have been cut. The dendrochronologist Pentti Zetterberg²⁶ has estimated the approximate but probable number of growth rings lost on the basis of the cellular structure of the logs, by which the fresh outer rings differ from the others.

The analyses shed light on two different factors in addition to simple dendrochronological dates. The wood in the charcoal pits, where whole logs were used, provided information on time-width and structures when it was cut. Namely, whether the trees were approximately of the same age and size, and if there was systematic cutting within particular areas. The analyses of the

26 Zetterberg (2006).

linings do not provide a similar insight, but the results are used for comparisons between radiocarbon dates and dendrochronological ones.

The evidence comprises in all 66 samples, of which 29 could not be dated because of poor preservation, too few annual growth rings, or poor agreement. The annual rings have nonetheless been counted on 17 of these samples. Both spruce and pine have been analysed. There are absolute reference curves for pine but spruce can only be relatively dated within its own floating sequence. Sites with samples of spruce, in other words, can be dated relative to one another but no exact age can be suggested. The results of the relative chronology are presented in the excavation report²⁷ but will not be used in the wider discussion as I consider the associated radiocarbon chronology to be inadequate.

Counts of Annual Growth Rings

The counting of annual growth rings showed that the age of the wood ranged from 30 years to 201. This shows that the samples analysed had a relatively large time-width at the point of cutting. In several cases there is an implicit probability that the age of the wood lay in the range of 30–40 years. This is linked to its quality and energy value, amongst other things, but also to the cycles of use. Since dendrochronology has also shown that the true age can be up to 200 years, however, it is difficult to date periods shorter than 300 years. A good example of this is the attempts to date sequences in the slag heaps at Jfp.5, where the bottommost layer in SH1 (AD 1255–1290, TUA-4448, 760 ± 35 BP) has a later ¹⁴C date than the uppermost layer (AD 1040–1180, TUA-4449, 915 ± 35 BP). Comparable results are also familiar from ¹⁴C dates of slag heaps from the Early Iron Age.

Charcoal pit Jfp.11-6—Time-Width and Date of Cutting

Charcoal pit Jfp.11-6 was not emptied after burning (see Ch. 3, Charcoal pits) and the wood was subjected to systematic dendrochronological analysis. Fourteen logs were analysed, five by the dendrochronologist Bartholin and nine by Zetterberg.²⁸ The annual growth rings in the wood range from 60 years to 166, and the mean is 115 years (Tab. 5.3). One must assume that the wood had been cut at the same time and that the variation reflects the flaking off of outer wood. The time-width is not absolute as all of the samples except one lacked bark and sapwood. Three of the logs have a determined date of cutting with a margin of error of 10–25 years. In six cases, the dating is given as a *terminus post quem*. The remaining five could not be dated. The dating given for the outermost preserved growth ring represents when that was formed and not the date of felling.²⁹

27 Rundberget (2007) 317–321.

28 Bartholin (2005); Zetterberg (2006).

29 Zetterberg (2005).

TABLE 5.3 *Dendrochronological dates and felling dates for wood in charcoal pit Jfp.11-6*

No.	Lab. Reference	Own age	Datings	Date of cutting
1.	NoHo142	135 year +	AD 1086–1221	After AD 1221
2.	NoHo143	60 year +	AD 1095–1155	After AD 1155
3.	NoHo144	145 year +	AD 1075–1220	After AD 1220
4.	NoHo145	70 year +	AD 1080–1150	After AD 1150
5.	NoHo146	157 year +	AD 1096–1253	After AD 1253
6.	NoHo147	103 + min 6 year	AD 1078–1181	After AD 1187
7.	NoHo148	154 + 8–18 year	AD 1097–1251	AD 1259–1269
8.	NoHo149	128 + 15–40 year	AD 1080–1208	AD 1223–1248
9.	NoHo150	136 + 30–50 year	AD 1077–1213	AD 1243–1263
10.	350001	88 year	—	—
11.	350002	81 year+?	—	—
12.	350003	114 + ca 50 year	—	—
13.	350004	69	—	—
14.	350005	62	—	—

The dates show that the first dated annual growth of the timber (samples 1–9) lies within a relatively narrow period, AD 1075–1097. This means that the wood started to grow at around the same time and that the timber may have been selected because of its age. An alternative possibility is that this age represents the reuse of the forest following a deforestation before AD 1075. The last known living year of the logs ranges, however, between AD 1150 and AD 1269. The problem of lost outer rings is thus manifest. There is, however, a quite regular relationship between time-width and date of cutting, as the timber with the fewest growth rings also has the earliest date (Tab. 5.3, and Fig. 5.2). The date of cutting thus appears, as anticipated, to have been the same. One ^{14}C date was obtained from one of the logs in the charcoal pit. The sample was taken from the outer edge of the log and the calibrated age is AD 1030–1230 (T-17324, 895 ± 75 BP). This ^{14}C date is earlier than AD 1269, and must likewise be attributed to loss of outer rings.

Several contexts have both radiocarbon and dendrochronological dates (Fig. 5.3). In eight cases, the same piece of wood has been dated, and in six the dated material is from different sources. This was done so that the dating methods could be compared. A general result is that the dendro-date, with one exception, falls late in the distribution range of the calibrated radiocarbon dates, as one would expect. This is also the case with several of the samples where the same source has been used even though it was the outer growth

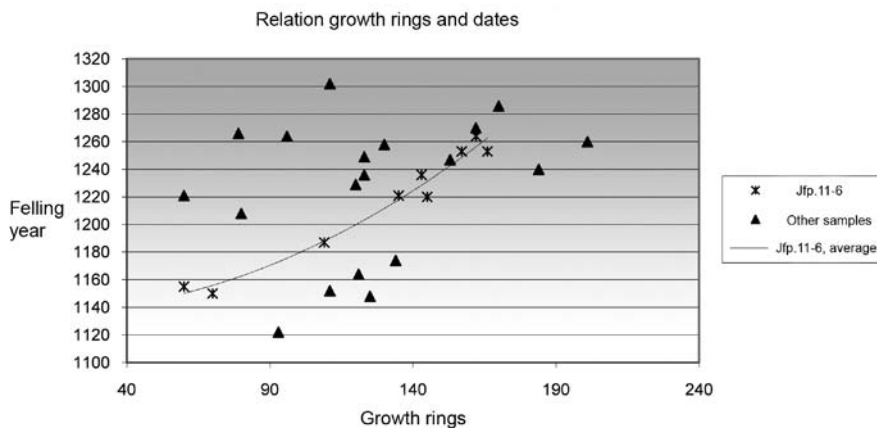


FIGURE 5.2 Relationship between growth rings counted and dating from the dendrochronological studies

rings which have been dated. In these cases, one would expect the dendro-date to lie around the middle of the probability range of the ^{14}C dates. Nonetheless a clear difference appears. In the case of the 3 charcoal pits where this was done, the dendro-date agrees more closely with the radiocarbon dates than in the case of the ^{14}C dates obtained from staves in isolation pits. The connection looks clear. The timber in the isolation pits has been trimmed and it is likely that long sequences of the outer wood have been removed. The results from the dendrochronological analyses are included in the analyses that follow when the phases of use of individual sites are discussed.

The Bayesian Approach—Precise Dating of the Period of Use

Period of Use and Phasing of Bloomery Site Jfp.3

In this section, the ^{14}C -date evidence from bloomery site Jfp.3 will be used to demonstrate the potential of the Bayesian method in chronological interpretation. The site was described in Chapter 3. It consists of two production sites. There are eight dates from the site, 12 from the charcoal pits surrounding it, and a dendrochronological date from one charcoal pit. A key question is whether the production sites were contemporary, whether they overlap, or whether there were two separate sequences of activity. I have already argued that several production sites at the same site can be seen as reflecting reorganization due to lack of space. The site may thus have several phases of use but the difference in time would not necessarily be more than a single season. In

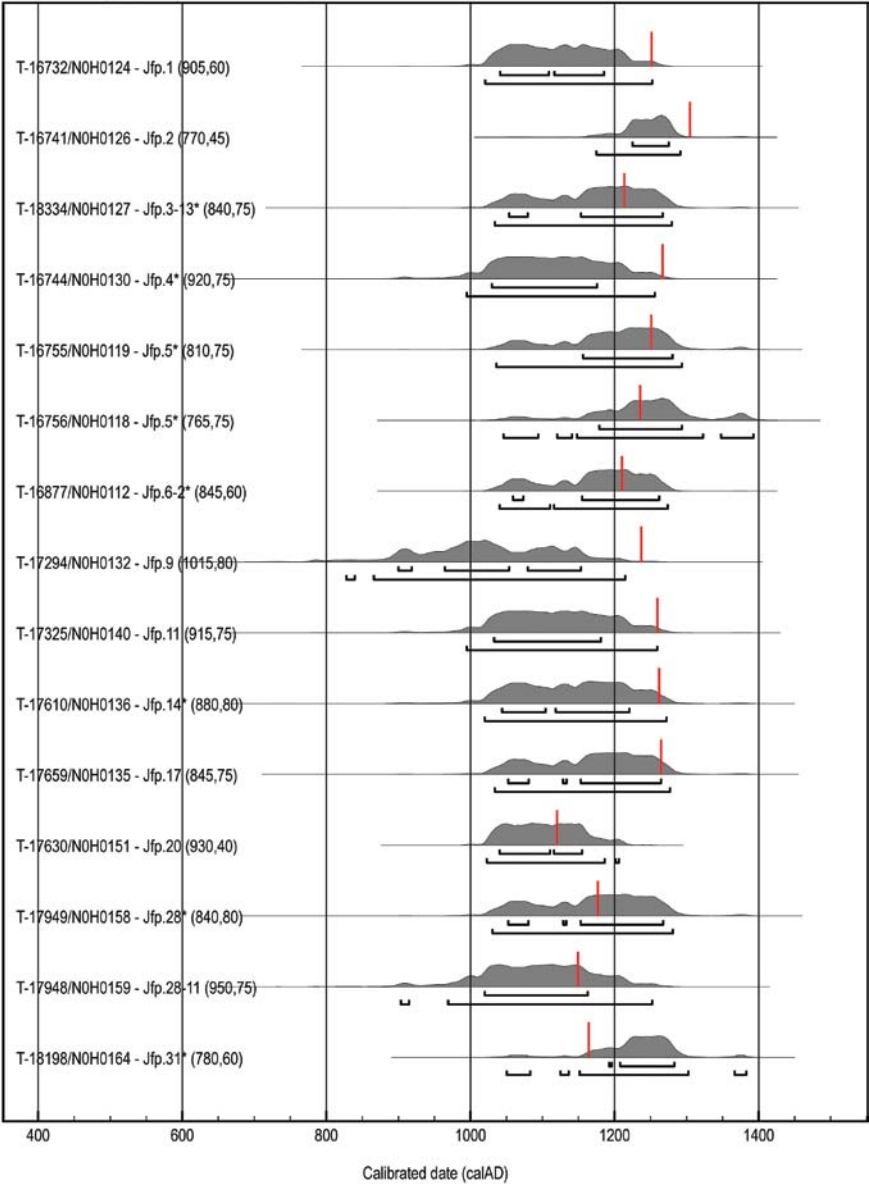


FIGURE 5.3 Samples that have been both dendrochronologically and radiocarbon dated. The earliest date of felling is included in the calibration diagrams. An asterisk * shows that the dating has been carried out on the same material. Bloomery sites labelled Jfp.x and charcoal pits Jfp.x-x
OXCAL V4.1.4 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER ET AL (2009)

Table 5.4 one can see that the uncalibrated ^{14}C dates from production site 2 are earlier than all of those from production site 1. For this reason, I infer that production site 2 was the earlier and that work there ceased for some reason or another. As the description shows, some of the discarded slag lay in very wet land. One explanation, therefore, could be that water and moisture caused problems during smelting. What is certain is that the ironmakers abandoned their work here after only a short period and subsequently cleared a new site on a dry morainic ridge close by.

By using the sum command in OxCal, as noted, a particular distribution called 'sum' is produced. This range of probability shows the combined statistical probability for when the activity took place, here at 95.4% probability. In Figure 5.4, the samples are calibrated and the sum distribution at the top, here labelled 'Jernvinneanlegg Jfp.3', shows the calculated period of use. With this, the problems of the great variability of the calibration curves appear clearly. Sample TUa-4445, for instance, has three separate areas of substantial probability for the activity. This, however, is scarcely represented in the sum curve. The sequence of activity covers nearly four centuries, an unrealistic result in light of the low level of production at this site. I consider the cause of this long range to be the old material/pine (*informative prior beliefs*) and/or the fact that some samples have conventional dates (T-numbers) while others have accelerator dates (TUa-numbers) (*uninformative prior beliefs*). This, however, is not reflected in the sum curve which sets the sum of the ^{14}C dates to =1, and so the outer areas of the sequence are hidden.

By using the Bayesian method, the picture becomes more credible, both in the case of individual ^{14}C dates and of the ^{14}C dates put together. One of the

TABLE 5.4 *Datings of bloomery site Jfp.3 given as ages BP. The sequence has been determined on the basis of a Prior belief, directed by chronological and stratigraphical considerations*

Context		Sample no.	BP-age	Deviation $\pm$ BP
Prod. site 2— phase 1	Furnace 3, stave	T-17660	1070	65
	Furnace 4, stave	T-17661	1025	40
Prod. site 1— phase 2	Slag heap SH 1	TUa-4445	975	35
	Slag heap SH 2	T-16747	875	75
	Fire place	TUa-4444	865	35
	Stockpile of charcoal	T-16746	770	45
	Furnace 2, stave	T-16748	865	75
	Furnace 1, stave	T-16749	710	75

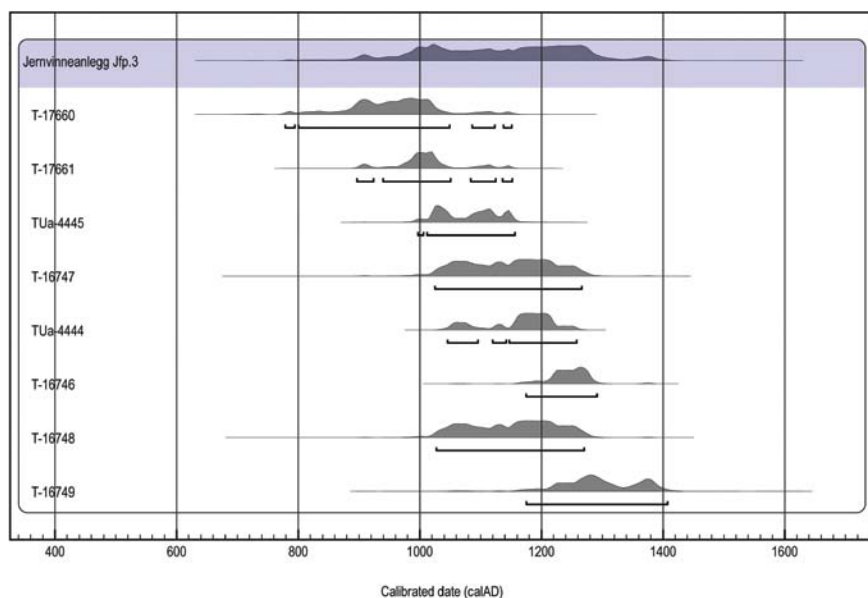


FIGURE 5.4 *Summary of the dates at bloomery Jfp.3*

OXCAL V4.1.4 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER ET AL (2009)

advantages of this method is that through modelling one can introduce a start and end point. This is produced by the command 'Boundary', which stipulates that the group of ^{14}C dates is evenly distributed within a single phase. In OxCal it is also possible to use a greater number of less value-neutral models of the distribution of Boundary³⁰ based upon various *Prior beliefs* one may have of the actual events.

The modelling requires the establishment of a sequence from the earliest to the latest. In this connection, it is necessary, for example, to assume that a charcoal sample from the base of a slag heap is earlier than a charcoal sample from the furnace that is evidence of the last round of production. Stockpiles of charcoal and ore must likewise be assumed to be later than the base layer of the slag heaps. At Jfp.3 there are no problems with major disagreement between stratigraphy and ^{14}C dates, and the situation is consequently relatively uncomplicated. One issue that nonetheless appears very clearly is that the dates reflect a chronological break. The dated furnaces at production site 2 are both earlier than the ^{14}C dates from production site 1. I interpret this in terms of there having been a period at Jfp.3 when there was no activity at the site. A second problem is the ^{14}C date of furnace 2 (T-16749) which indicates

30 Bronk Ramsey (2009a) 345–347.

disproportionately late activity. Could this have been so? In Table 5.4, a *Prior belief* for the chronological sequence at the ironmaking site is presented.

It is possible to include parameters for phases of use in the model, 'phase 1', 'phase 2', etc., for however many phases one wishes. The key principle is to identify which samples belong to which phases and to group these. It is also possible to introduce a parameter that determines to what extent two phases are continuous with one another or whether there is a break ('overlapping'). The term 'overlapping' indicates that it is possible to distinguish two overlapping phases which are not directly related. I have a *Prior belief* of a break at the site and therefore use 'overlapping'.

A further command, labelled 'Outlier', can be introduced as a variable in order to adjust for possible errors or inconsistencies in the samples. In the case of *jernvinna*, it is the time-width of the wood which often causes problems. The Hedmark area saw widespread use of pine, the time-width of which can be more than 200 years. The charcoal is always older than the context. The difference in time is usually small, but the charcoal can be much older. In statistical terms this can be expressed as an exponential distribution in which we do not know a time-constant (more than 1 year but less than 1,000 years). This model is introduced as a parameter with each charcoal sample. The ^{14}C dates are analysed in relation to one another and possible time-widths are cleared away.³¹

After all the dates and parameters have been entered, the programme runs a series of calculations, dependent upon the quantity of data and the complexity of the model. It is possible to keep track of the number of calculations performed and the convergence in the calculation. After the calculations have been completed, the result of the analysis is presented in a figure in which both the pre-modelled and modelled calculations are shown. The agreement of the individual samples (A) between *Prior beliefs* and *Standardized likelihood* (Amodel) and the overall agreement (Aoverall) are also shown here.

The output of the modelling can be visually presented in several ways. Most comprehensible is the 'Multiple plot' in which both individual dates and the Boundary parameters are shown (Fig. 5.5). The whole model is defined as a *Sequence* while *Phase* denotes the various phases. *Posterior beliefs* are shown in grey while *Prior beliefs* are represented by a black line. It is thus clearly apparent where the analysis has discounted parts of the original distributions of date ranges as improbable. Finally, Boundary is calculated. Two curves are presented, one for the date range of the start and one for the date range of the end of activity. The curve should ideally be conical, albeit with a rounded top, which makes its interpretation easier.

31 Bronk Ramsey (2009b) 1028, 1030–1032.

The Period of Use of Bloomery Site Jfp.16

At Jfp.16 (see Ch. 3, Bloomery ironmaking in the Gråfjell area—form and facts, for details of the material sampled), four ^{14}C dates were obtained. These fall into two groups, with poor correspondence between them. Two ^{14}C dates are from the bottom layer of the charcoal stockpile (TUa-5308, 1185 ± 85 BP, cal AD 820–890) and the slag heap (TUa-5309, 1160 ± 30 BP, cal AD 880–955), one sample was taken from a wooden log which is believed to have been part of the construction for the store of charcoal (T-18465, 945 ± 60 BP, cal AD 1020–1170), while the last is from the furnace (T-17638, 865 ± 65 BP, cal AD 1050–1255). The samples from the base of the slag heap and the charcoal stockpile are interpreted as being connected to other activities. A large area around the bloomery site was deturfed, and this thin layer of charcoal was found in several places. The charcoal probably represents the clearance of the area and it is logical to interpret the burnt layer as an early use of the shieling site where there is evidence of pasturing and cultivation both in the Viking Period and in the Middle Ages, from the thirteenth century (see Ch. 3, Iron bloomery sites—earlier investigations and state of research).

With only two ^{14}C dates that can be securely linked to ironmaking, more samples should be included. The charcoal pits which are definitely linked to the single site can be added here, and this connection is clear as Jfp.16 lies in an area with no other known iron production. A consideration which supports this is that the number of charcoal pits and phases of charcoal burning seems to correspond very nicely to the volume of production at the site (Fig. 5.6). The analysis points as a result to activity here in the period c. AD 1175–1250. This indicates a later period of use than if we interpret the ^{14}C dates from the bloomery alone, which have very wide date ranges.

The Period of Use and Phasing of Bloomery Site Jfp.20

At Jfp.20, seven ^{14}C dates have been obtained, all of them from pine. The calibrated dates fall within the period AD 1000–1305. If we look at the ^{14}C dates of the furnace, these could indicate either two phases of use, or that furnace 1 (T017628, 735 ± 75 BP) was in use for longer than furnace 2 (T-17630, 930 ± 40 BP). A dendro-analysis of furnace 2 (NoH0151) shows that the wood in the lining was cut after AD 1122, probably very few years after that. I have introduced a margin of 10 years (1122–1132) as probable. The ^{14}C date from the same piece of wood agrees well and the final phase of use of the furnace can be established with considerable confidence. This is included within the model and appears as three date ranges: one for the radiocarbon date, one for the dendro-date and one in which these are combined.

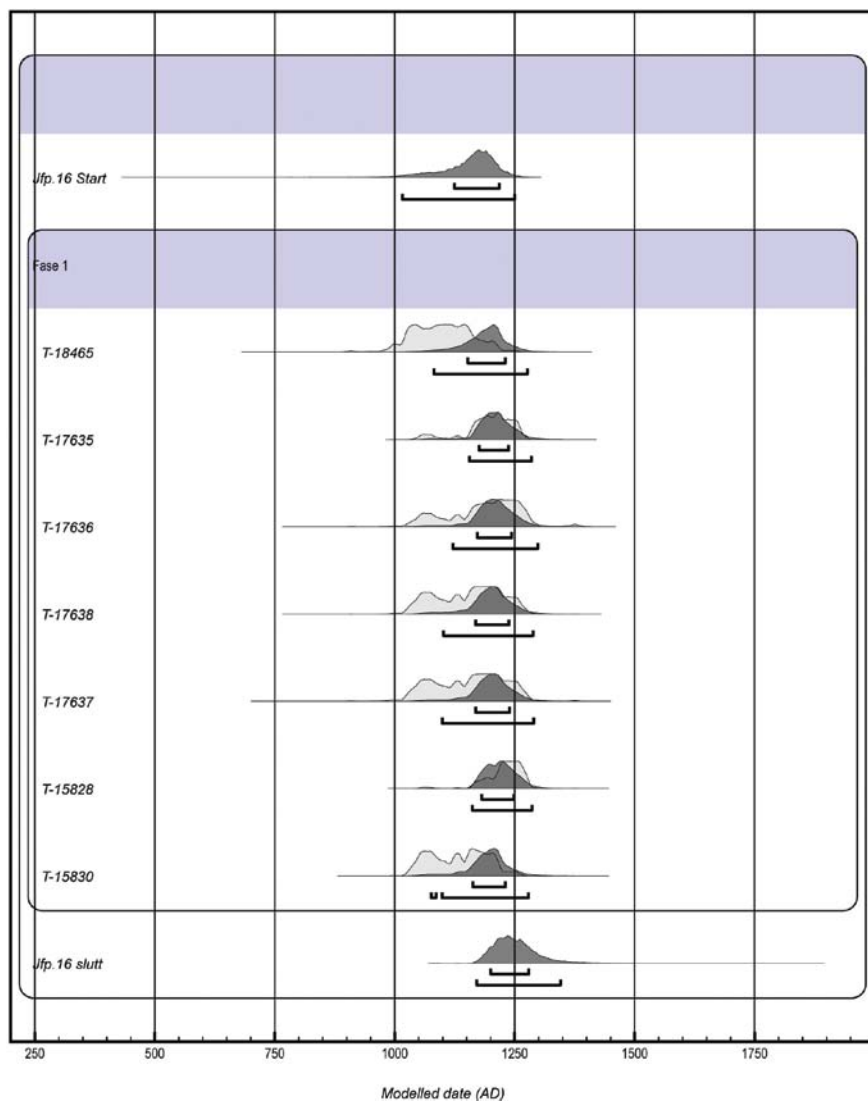


FIGURE 5.6 *Modelled dates from Jfp.16. It is clear that considering the dates together and undertaking a statistical calculation of probability reveals it to be most likely that the activity took place sometime between AD 1150 and 1240*

OXCAL V4.1.7 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER ET AL (2009)

As is evident, there are difficulties in including the dendrochronological dating (Fig. 5.7). The programme is constructed so that with a date range of only 10 years the others are markedly constrained, as is logical in that here we are dealing with an absolute dating. This appears particularly in the date range for

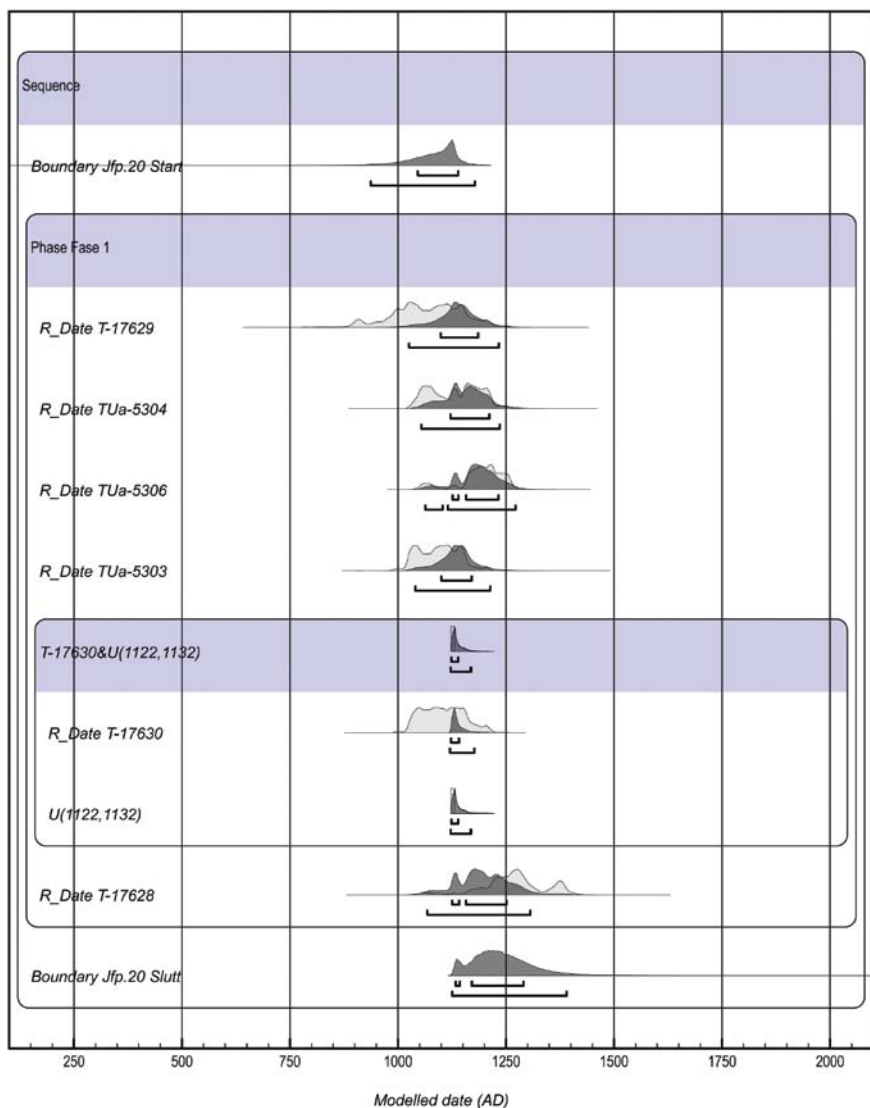


FIGURE 5.7 *Modelled dates from Jfp.20, including the absolute dendro-date from furnace 2. It can be seen that this affects the relative dates of the charcoal*
 OXCAL V4.1.4 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER ET AL (2009)

'Jfp.20 start'. It is clear that the start cannot lie after AD 1132, but that the curve also rises sharply just before AD 1122 is a weakness. In the process of interpretation, we have to take this into account. The impact it has can be tested by excluding the dendro-dating and comparing the distributions with one another (Fig. 5.8). 'Jfp.20 start' now follows another pattern. The wide range of the dates

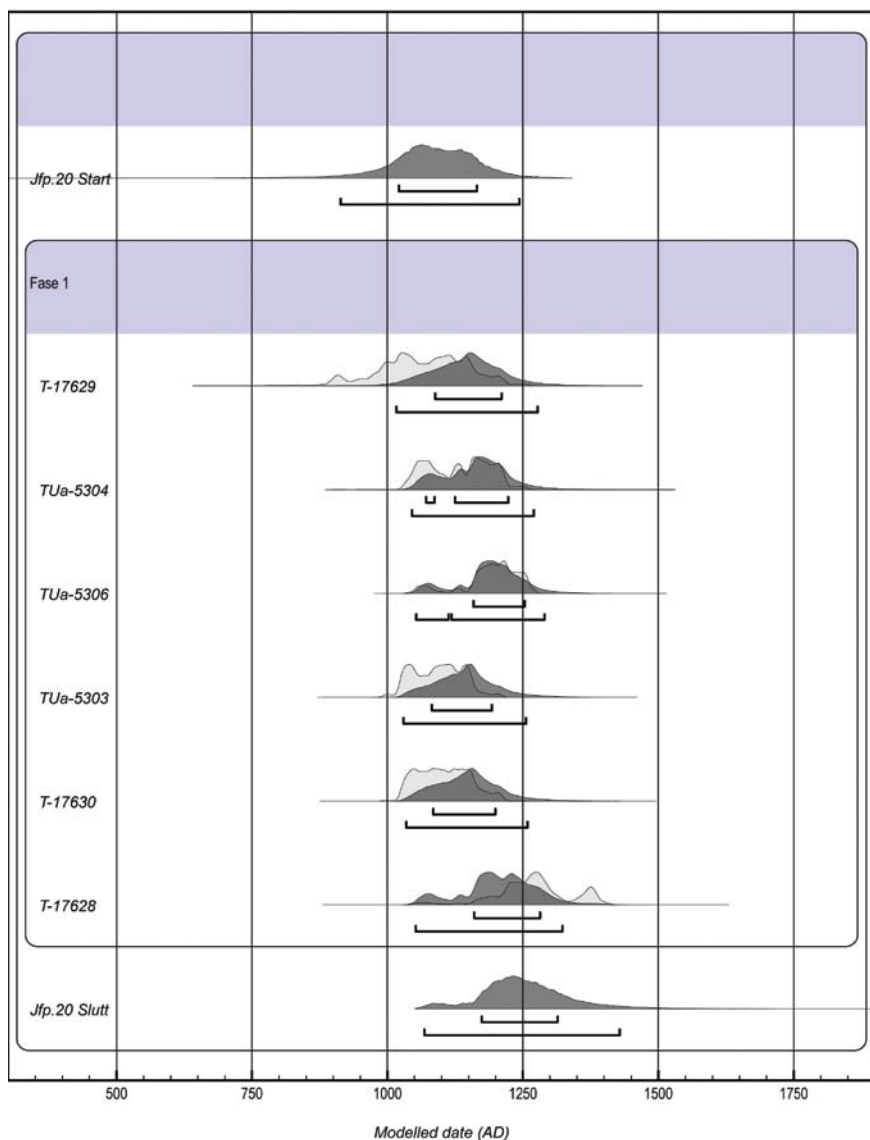


FIGURE 5.8 *Modelled dates from Jfp.20, not including the dendro-date from furnace 2. This makes the starting point of the activity earlier and introduces greater uncertainty* OXCAL V4.1.4 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER ET AL (2009)

means that the start is suggested to lie most probably in the period AD 1050–1150. The modelling of the individual charcoal samples does in fact show that the beginning was probably closer to 1150 than 1050. By comparing the two models and their distribution, I consider it most probable that production here took place in the period 1100–1200.

The Gråfjell Area—a Specific Chronology

Period of Use of the Bloomery Sites

By using the Bayesian method to interpret the large number of ^{14}C dates, the probable sequence of activity can be brought into significantly narrower focus. This is clearly expressed in Figure 5.9, where calibrated and modelled results for the sites analysed are compared. Several features appear here. In the case of the great majority of sites, it transpires that it is the beginning phases where we encounter the most frequent and the greatest narrowings of the period of use. At the end of the activity, in most cases we have only minor changes, if any at all. In some cases, the modelled ^{14}C dates suggest a somewhat longer period of use. The explanation of this lies in the use of ‘Outlier’, which brings possible time-widths into the analysis. In practice, this means that as well as constraining the sequence of activity I have also moved the activity on in time somewhat.

This is clearly expressed when we look at the distribution of periods of use in 50-year intervals (Tab. 5.5). The calibrated results implied a relatively high level of activity before and around the year 1000. Activity then increased steadily to a peak in the later twelfth century and the beginning of the thirteenth century. Around the year 1300 or shortly before, activity comes to a relatively abrupt end.

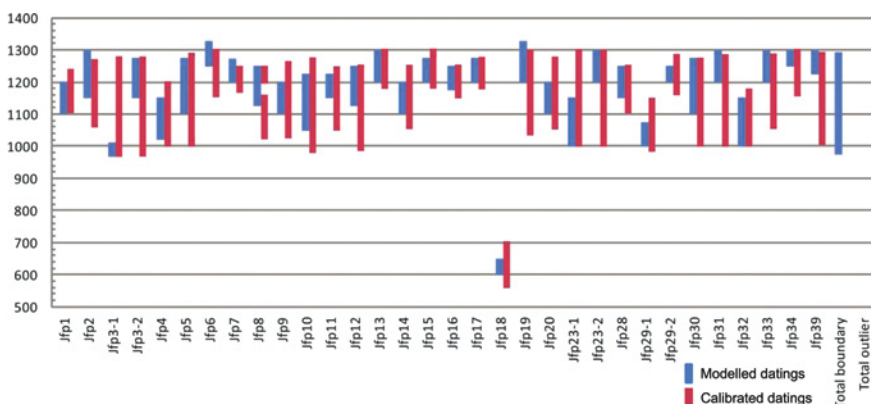


FIGURE 5.9 *Calibrated and modelled interpretations of the periods of use of bloomery sites in the Gråfjell area. Only sites with more than three dates have been included. At sites with two phases and a break in activity (Jfp.3, Jfp.23 and Jfp.29), the calibrated result and the modelled phases are compared. This consequently produces wide ranges*

The modelled ^{14}C dates produce a different picture of development. Only one site has a start before AD 1000, and the production was very limited throughout the eleventh century. Only after the beginning of the twelfth century did production increase noticeably, and it reached its peak only in the thirteenth century. There is then a fall in production around 1250 before it ceases completely around 1300.

Another very important aspect must be noted. The calibrated results indicate that there had been many more sites working at the same time than the modelled results indicate. This number represents the number of people who took part in this production, and the difference between 5 and 19 sites in the period 1050–1100 constitutes a great numerical discrepancy in the need for labour. 29 bloomery sites are included in the analysis, about 25% of the evidence recorded in the Gråfjell area. In statistical terms, the number can therefore be multiplied by four. This would mean that as many as 80 bloomery sites could have been in use in the period 1200–1250, a figure that can only with difficulty be reconciled with the known matriculated farms. These points will both be discussed in due course.

One detail that I attempted to test, but without success, was whether there are chronological boundaries within the activity inside the Gråfjell area. The modelled results show that exploitation varied over the whole area, in the form of use and reuse, and that production has to be seen as part of a single phase of use.

TABLE 5.5 *Iron production in the Gråfjell area in terms of sites active within 50-year periods*

Iron bloomery in intervals of 50-years	<i>Numbers of operating bloomeries</i>	
	<i>Calibrated interpret.</i>	<i>Modelled interpret.</i>
AD 950–1000	4	1
AD 1000–1050	13	4
AD 1050–1100	19	5
AD 1100–1150	21	12
AD 1150–1200	27	14
AD 1200–1250	26	20
AD 1250–1300	18	15
AD 1300–1350	—	2

The Gråfjell Area Compiled

Above, I have primarily discussed the sequence of activity at the individual bloomery sites as separate units. In two cases (Jfp.16 and Jfp.17), charcoal pits have been included in the analysis. This is because we only have two secure 14C dates from these sites, and these are located far from other production sites, so that we can link the charcoal pits with the bloomeries with a high level of confidence. Another way of running the analysis is to include the certain charcoal pits and exclude the uncertain ones. But since I have chosen to concentrate on the bloomery sites here, it is most appropriate only to use samples from these.

The 14C dates of the charcoal pits, however, are used in the wider analysis, where I look at the period of use as a whole. This is also the case for bloomery sites with only one or two 14C dates. Altogether we can include 189 14C dates from bloomeries, 131 from charcoal pits and 10 from roasting sites. I have chosen to use the distributional model Boundary, as the number of samples can statistically be counted as representing a uniform distribution across the whole period of production. A possible alternative would be to use Outlier. However, the tests I have run show that if Outlier is used on such a large collection of evidence, the data is calculated as a single event and not a relatively long period of use as the distribution of the dates would indicate.

The result agrees well with the dates of the individual sites. The starting point for the whole phase and the earliest bloomery sites overlap very well just before AD 1000. There is, however, a small discrepancy over when the activity came to an end. From the modelled 14C dates, 15 sites are suggested to have seen production in the period AD 1250–1300, of which several appear to have continued up to AD 1300, but only two continue into the fourteenth century. In the overall date range, on the other hand, the end is defined as having come about by AD 1290 at the latest. These are not great differences, but what probably explains the shift is the use of Outlier (the time-width of the timber/charcoal) in the modelling of the sites. A variation of 10–20 years is an acceptable figure in this context. Taking this into account, the calculations using OxCal imply that *jernvinna* in the Gråfjell area began around AD 975. The activity then increased gradually to a peak around AD 1200–1250. In the course of the final decades before AD 1300 the whole activity was relatively rapidly abandoned (Fig. 5.10).

14C Dates at Rødsmoen

Rødsmoen practically borders the Gråfjell area, but I have decided to look at the 14C-date results separately, because it is interesting to compare two such adjacent areas. At the same time, Rødsmoen saw a somewhat different

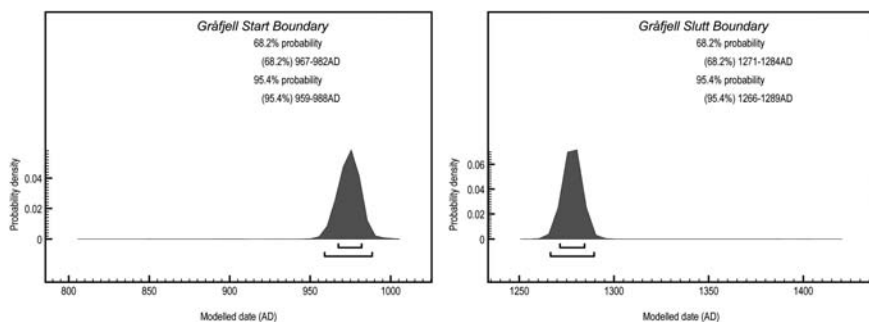


FIGURE 5.10 *Modelling of the start and end of jernvinna in the Gråfjell area. The model incorporates 330 dates on pine and spruce, of which 189 dates are from bloomery sites, 131 from charcoal pits and 10 from roasting sites*
 OXCAL V4.1.4 BRONK RAMSEY (2010); R:5

development, as several bloomery sites from the period before the Hedmark tradition are known here.

The evidence is made up of 34 ^{14}C dates, from six bloomery sites and 12 charcoal pits (Fig. 5.11). The calculations that have been done with the Rødsmoen evidence agree well with the Gråfjell area. Both the start and the end have longer date ranges that overlap well. In both cases, however, it is the case that the peak of the curves appears a bit later than is the case in the Gråfjell area. This indicates that production in Rødsmoen could have started and ended somewhat later, but in either case it does not lie outside the range of the Gråfjell area. This also means that the more central forest areas that Rødsmoen represents, from their position closer to settled districts, were not brought into use before the more peripheral areas such as the Gråfjell area represents.

The Dating of *jernvinna* in Hedmark

A fundamental question is whether or not there was a common start and end to this activity across the region. Outside of Gråfjell and Rødsmoen there are no bloomery sites with more than one ^{14}C date, and the dated sites are also markedly scattered over the region. However, a number of charcoal pits have been dated, as well as the bloomeries. If all the ^{14}C dates are added together it is possible to look for a consistent pattern in the history of production or consider whether there are internal chronological differences. In order to generate an overview of this, areas have to be compared with one another, and I have distinguished the following 6 areas:

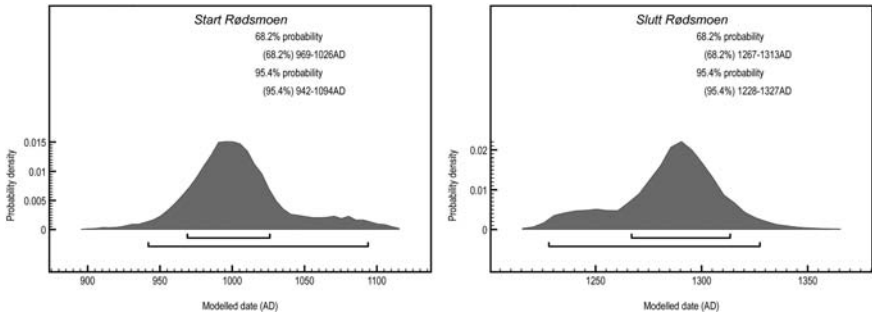


FIGURE 5.11 *Modelled views of the start and end of ironmaking activity associated with the Hedmark tradition and at Rødsmoen. 34 dates from Rødsmoen are incorporated in the model. Both the start and end points are approximately contemporary with the Gråfjell area, but in both cases the peak of the curves lie 10–20 years later than those of the Gråfjell area.*

OXCAL V4.1.4 BRONK RAMSEY (2010); R:5

Region_South—Solør

Region_Våler

Region_Elverum

Region_West—Ringsaker, Løten and Hamar

Region_North—Trysil, Åmot, Rendalen and Stor-Elvdal

Region_Värmland—Torsby (Sweden)

There are few clear topographical or geographical features that delimit these areas. Clear boundaries are also elusive except in the case of the national and administrative district boundaries. Consequently, the areas could have been constituted differently. It is, however, very problematic to go right down to the level of the administrative district as in many cases the amount of evidence is very small. The boundaries of the municipalities are also only artificial lines in this respect. They are, nonetheless, very easy to employ from the topographical records, and for this reason are used as the basis for defining the areas.

Region_North is defined as a unit because there are few ¹⁴C dates from all of the districts, except for Åmot. *Region_West* has been chosen because the area lies west of the River Glomma and in the forests down to the Mjøsa. After having reviewed the area, the ¹⁴C dates provide no basis for splitting this region up any further. I shall give full attention to a problem which arises with particular reference to this area.

In the central and southern areas, I have carried out several alternative modellings. An attempt was made to treat Våler and Elverum as one area, and to include Våler in the southern area. Both experiments produced problematic

results. In several cases, agreement was not satisfactory ($A < 60\%$). This did not mean that Amodel fell below 60%, but I decided nonetheless to run new models. The best agreement was obtained by dividing Våler and Elverum as two separate areas and to allow the southern area to consist of Solør without Våler. Torsby in Värmland is distinguished as a separate area from the national boundary which can definitely be dated to as early as the Middle Ages (see Ch. 7, The written sources).

A critical problem with the division into areas selected is the variation in the number of samples that can be included in the analysis. Inconsistent individual ^{14}C dates in areas where the sample size is small have greater consequences for the calculations than when there is a large number of samples. The result is that areas with a large number of ^{14}C dates produce better date ranges for the start and end points. The distribution of activity within the given period is also an element to keep an eye on. If the distribution of the dates is regular within the period one is considering, then one has a better foundation for discovering the start and end points than in cases where there is a cluster of dates at one end of the sequence. A relevant point is that in many cases it is the final phase of use that has been dated, and this is particularly so in the case of charcoal pits that had been reused.

This is most clearly evidenced in the attempts to model *Region_West*. A high percentage of the ^{14}C dates here fall within the period 1150–1300, while only a minority belong to the early period of use. This could mean that, on statistical grounds, production had a later start here, but the number of ^{14}C dates

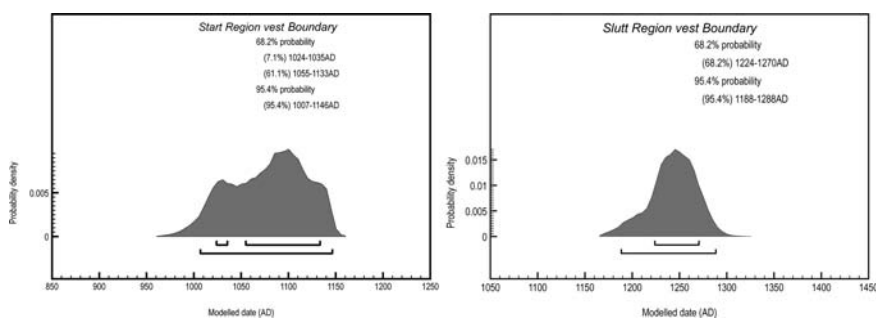


FIGURE 5.12 Calculation of the start and end points in *Region_West* assuming a uniform distribution of the dating evidence (*Boundary*). The problem becomes clear when interpreting the start point, as the dates from the first part of the phase are few and scattered compared with later on. Compare with Figure 5.13, where the command *Zero_Boundary* has been used

OxCal V4.1.7 Bronk Ramsey (2010); R:5

from the period 950–1150 is so high that I find that unreasonable. This distribution, combined with a relatively small collection of evidence, makes the job of analysis difficult. Statistical calculations run on the evidence result in many samples coming out with poor agreement. The A score fell as low as 1.8% for one sample and Amodel was an index of agreement of only 59.8%. This again leads to the probable starting point being very difficult to determine from a widely spread date range (Fig. 5.12).

On the basis of the analyses from the Gråfjell area and other areas which provide good agreement, I consider that it is overwhelmingly probable that the result is due to one or more flaws in the data. The problem lies most probably in uneven distribution. I have consequently decided to introduce a *Prior belief* from the Gråfjell area which shows that production gradually increased. This would mean that the distribution of the 14C dates should also be steadily rising. This pattern of distribution is provided by a distributional model called 'Zero_Boundary'.³² Using this, the programme takes account of there being a gradually rising or falling distribution in the material, and that a small but representative proportion of the 14C dates either early or late in a phase should not necessarily be regarded as misleading. In this case, one can cope with the skew in the evidence from *Region_West* by the introduction of Zero_Boundary at the start.

When introducing the Zero_Boundary command in one area, one has to consider whether it is appropriate to do the same in the other areas. It is to be noted that this command can only be used at the start, as the Gråfjell area, which is the reference area here, indicates that production came to a rapid end. Models have been run both with and without this command and the results are rather varied. The most problematic is *Region_South* where the start moved more than a century earlier. Production was suggested to have had a rather earlier start, but the end date was not noticeably altered. Only 11 samples are included in this model and several of them have early 14C dates. By using Zero_Boundary on this evidence, the programme interprets the activity as having seen a start that is too early because of the length of the conventional date ranges. This is thus the opposite effect of that with *Region_West*.

In *Region_North* too, production was moved about 50 years back in time by the use of Zero_Boundary. On the basis of the Gråfjell area, which has provided the great majority of the evidence, I consider this to be misleading. The problem here too probably resides within the distribution of the dating evidence. Although, in terms of the discussion above, there is a lower percentage of samples that fall in the first part of the period, the samples are so numerous and the date ranges so long that the programme suggests a start that lies before

32 Bronk-Ramsey (2009a) 345–347.

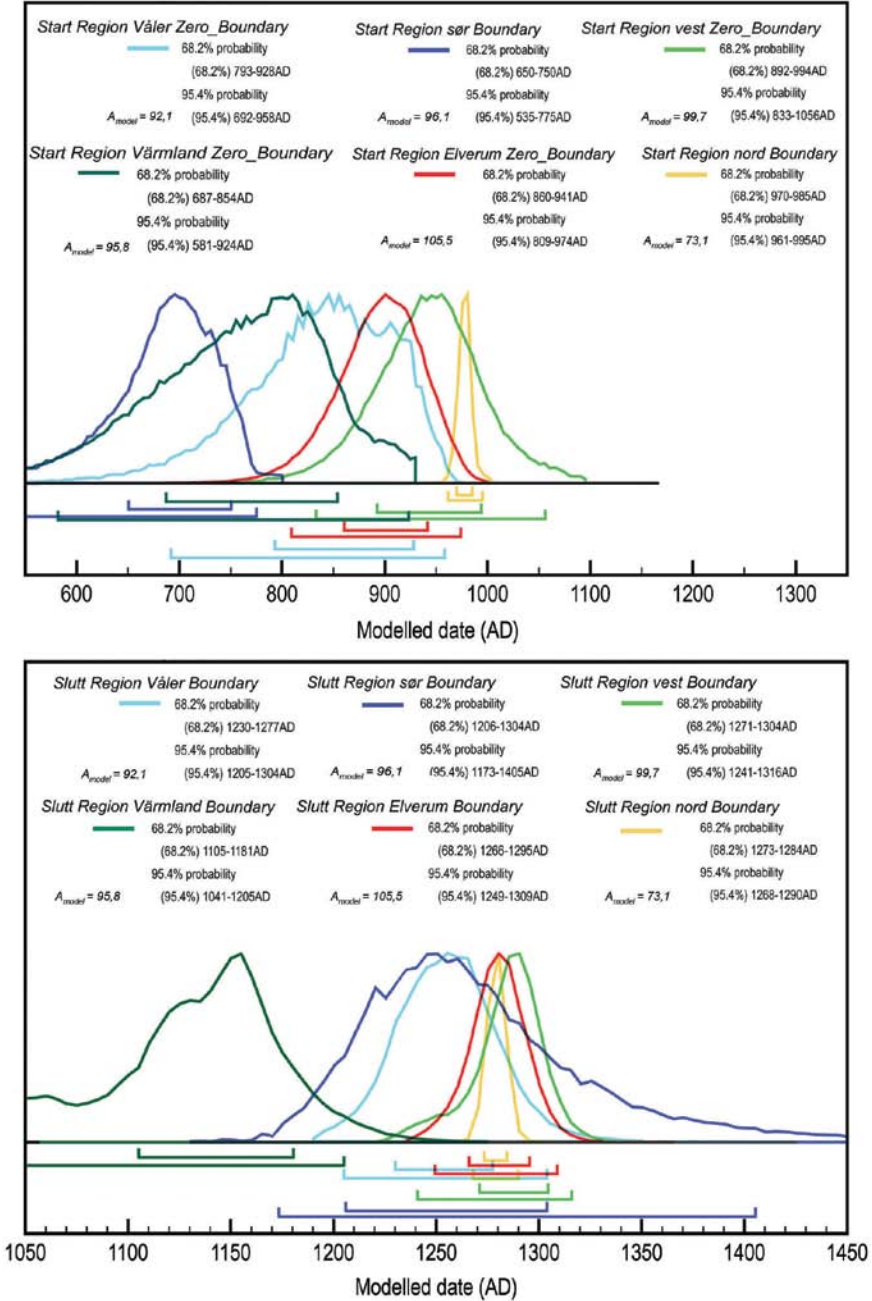


FIGURE 5.13 The start and end point for the six regions defined. The picture shows unambiguously that production began in the southern and eastern areas before spreading out gradually to the north and west. A clear trend is that production ended much earlier in Värmland than elsewhere. It also appears that the activity ended some decades earlier in the south and in Väler, compared with the western and northern areas OXCAL V4.1.4 BRONK RAMSEY (2010); R:5

what really was the case in the Gråfjell area. In *Region_South* and *Region_North*, I have therefore decided to use a uniform distribution as the basis.

In the case of the other two areas, the different commands produced only small variations. *Zero_Boundary* has been used in both cases as the final part of the period here, too, appears to be somewhat over-represented in comparison with the reference area, *Region_North*.

The distribution is graphically presented in Figure 5.13, and the modelled results for the start and end points are collected in a summary diagram with contrastive colour codes. The difference in the probability scores has to be viewed in light of the number of 14C dates that are included in the analyses. *Region_South* has the worst result, with only 11 14C dates. At the other end of the scale lies *Region_North* with a total of 381 14C dates. Another fundamental critical problem in *Region_South* is that, as well as being few, the 14C dates cover a wide range of time. This is the only region, along with Torsby, with 14C dates as early as the late seventh century.

The results produced by the dating analyses are discussed and contextualized in the concluding chapters. At this point I shall simply pick out some general features of the pattern of distribution. The start point of bloomery iron-making of the Hedmark tradition appears to fluctuate. In the south, several 14C dates from reliable contexts indicate that production was beginning in the decades around AD 700. In Torsby too, production can be traced back to the eighth century. It then spread gradually northwards. In the ninth century, and very probably in the first half of that century, ironmaking was being practised in Våler, and around the year 900 production had also started in the forested areas around Elverum. After this it appears that production spread westwards towards Mjøsa in the first half of the tenth century, before it took its final step northwards around the year 950. The cessation of this activity was a quite different scenario. In Torsby, production comes to an end as early as the middle of the twelfth century. In the southernmost area and in Våler, it appears that production came to an end around AD 1250. In the three other areas, the activity ceased some decades later. Amongst other things, it is useful to note the very good agreement between the areas *Region_West* and *Region_North*. Here, too, it is evident that the basis for interpretation is poorer in the south, but the range of probability implies that the activity ended very abruptly and more or less at the same time across this whole, huge region. In the course of just a few years, very probably c. AD 1270–1290, the tradition was abandoned, never to be taken up again.

The Volume of Production from the Hedmark Tradition

One of my core propositions is that ironmaking was of such a high volume as to be a fundamental economic factor in the development of Viking Period and medieval society. The level is reflected in the large number of production sites, the majority of which saw a high volume of production within a limited period of time. The aim of this chapter is to deduce the probable volume of production in the study area, primarily based on the Gråfjell area. Three elements are fundamental: the calculation of the volume of the slag heaps; the relative quantity of slag and other fill in the heaps; and calculations of the ratio of slag to iron. Additionally, the consumption of ore and charcoal are crucial in reaching conclusions about probable volume.

Calculations of the Volume of Slag Heaps

Calculations of the mass of slag heaps can be undertaken by several methods. A sure result can only be produced by measuring and weighing the fill in its entirety. This method, however, requires much in the way of resources and is only rarely attempted. At bloomery site R695 in Rødsmoen it was done by shovelling the whole fill into buckets.¹ It was not done in the Gråfjell area.

A different method, which was used in this area, was to produce 3-D plans of the heaps by using a total station. The method is simple. Two models of the slag heaps are produced. The first set of measurements is taken after deturfing and the second after the heap has been removed. Up to 3,000 points were taken in order to plot the surface as fully as possible. After the measurements have been taken, the volume in between the two surfaces is worked out.² This method was regarded as reliable, and few critical evaluations of the results were undertaken. In hindsight, however, it is clear that the results of the measurements do not correspond to the actual size of the slag heaps in several cases. An important practical problem is that even small errors in the definition of the limits of the heaps, and especially of their height, lead to large margins of error.

¹ Narmo (1997) 57.

² Hill (2007) 37.



FIGURE 6.1 *The excavation of a slag heap at Jfp.32. The heap measured 7.8×4.6 m and was 0.9 m high. Its shape is thus oblong and, as the picture shows, it had a clearly rounded top.*

PHOTO: H. DAMLIEN, HMC

A third method is to use mathematical formulae involving measurements from surveys and from excavation. The formulae are based upon an ideal figure, something that is very rarely embodied in the actual shape of the heaps, so that one has to find a mathematical figure that approximates to the shape of the heap. In the Hedmark tradition, the slag heaps are usually oblong or oval, with a rounded top. In many cases, they remind one of an upturned boat (Fig. 6.1). The closest geometrical form is a half-ellipsoid. Different shapes occur. The greatest margin of error applies when the heaps are uneven or pointed, which is not uncommon. In theory, the volume calculated could be up to 36.3% too large (the difference in area between a triangle and a semicircle). In all cases, the slag heaps have curved edges, so this maximum discrepancy cannot occur. I have not taken the difference into account as it is impossible to determine the exact shape of the heaps. In order to ensure that the volume is not artificially elevated, I have reduced the total volume of production by 10%, around one-third of the error-margin referred to (see Fig. 6.2). Another source of error in the calculations is that all of the measurements are approximate. Under survey conditions, measurements are produced with error-margins of 5–20 cm. This inaccuracy, however, can be treated as working both ways, and so is not, in statistical terms, a major problem.



FIGURE 6.2 *Left: the formula for a half-ellipsoid is $(4/3\pi \times ABC)/2$, where A, B and C are the radius of length, height and width respectively. Right: sections through an oval and a pointed slag heap. Grey shows the maximum difference (36.3%)*

The first-mentioned method produces the best result, but is scarcely practical in field work when time is precious. The other methods both have weaknesses, but the inaccuracy should not necessarily be great. A point of reference for this is the two slag heaps at R695 at Rødsmoen, which were manually measured as having volumes of 25.9 m³ and 35.5 m³ respectively. The formula for a half-ellipsoid produces volumes of 23.5 and 33.4 m³ respectively, somewhat below the actual size. The relationship between the measured volume and the mathematical calculation, on the other hand, has produced much greater discrepancies. An example is Jfp.30 in the Gråfjell area, where the volumes of slag heaps 1 and 2 were measured using the total station as 12.5 and 12.4 m³ respectively. The formula for a half-ellipsoid puts the volumes as high as 36.6 and 40.2 m³.

By comparing this with the calculation of the volume of slag heap SH1 at Jfp.1 (Tab. 6.1), the source of error must lie in the calculations carried out using the total station. The slag heap at Jfp.1 is smaller in width and height but just as long as SH1 of Jfp.30. Nevertheless, the volume of the slag heap is measured as 5 m³ greater. When the measurements of the slag heaps are considered side by side in the table, they show that the volume measured using the total station is erroneous. What the actual source of error is with the measured data, however, is elusive. The correspondence between the measured volume and the mathematical volume, by contrast, is good, and I therefore regard the mathematical calculation as statistically satisfactory. The results of the calculations of volume of all slag heaps in the Gråfjell area and Rødsmoen are given in Appendix III. In the case of excavated sites, measurements produced after excavation are used, but for non-excavated sites the measurements are those recorded by NIKU. There are variations in the measurements and, in principle, unexcavated sites should have slightly smaller dimensions than excavated ones, because the base level lies beneath the turf. I have reviewed the measurements and observe that divergence goes both ways. There are several probable reasons for this. Different individuals carried out the measuring, which will always produce discrepancies. At the same time, surveyed measurements are produced

TABLE 6.1 *Measurements and calculations of volume of the slag heaps of R695, Jfp.30 and Jfp.1. There is good agreement between the measured volume and the mathematical calculation at R695. The agreement between the total station and the mathematical calculation is highly varied. Two examples are Jfp.1 and Jfp.30. In the former case there are good correspondences, but contrastively there is great disagreement at Jfp.30 After Johansen (1996); Narmo (1997) 57; Rundberget (2007) 201–202*

Site method	Measure, L*B*H	Volume, buckets	Volume, total station	Volume, ellipsoid
R695, K1	9,7 * 7,7 * 0,86	25,9	—	23,5
R695, K2	10 * 7,6 * 0,84	35,5	—	33,4
Jfp.30. SH1	8,4 * 6,5 * 1,3	—	12,5	36,6
Jfp.30. SH2	12 * 6,2 * 1,0	—	12,4	40,2
Jfp.1, SH1	8,3 * 4,4 * 0,9	—	18,7	17,2

before the turf has been stripped off the slag heaps. This adds several centimetres and compensates for whatever part of the slag heap lies beneath the turf. The surveyed height is also to a considerable extent higher than the height measured by archaeological investigation. We cannot therefore assume that the survey measurements produce too low a volume.

Calculations of Volume of Slag

The proportion of slag in the waste heaps of *jernvinna* varies from period to period and from region to region, and figures determined cannot be simply reapplied. Even locally there can be variance. In some cases, the heaps consist mostly of slag, while in others there is a lot of some other fill. To get some hold on the slag content it was therefore necessary to distinguish it from the other fill. This was done by taking out a representative, measured volume, in order to calculate the total weight by extrapolation. In the Gråfjell area, 0.25 m³ was removed from 19 slag heaps. The fill was measured in buckets, and weighed, before being water sieved. Slag, furnace fragments/shaft material, and other fill were separated from one another. The proportion of slag provided to be quite consistent from site to site, with a few exceptions. The total weight usually ranged from 406 to 500 kg. The mean value of this quantity is 459.5 kg. Slag was separated from other fill from nine slag heaps, and the weight of slag varied from 150 to 368 kg. The mean weight of slag in 0.25 m³ of fill is 293.8 kg, which corresponds to 1,175 kg slag per cubic metre. It can always be debated whether

0.25 m² is an adequately representative quantitative sample from which to derive the data for volumetric analyses. But based on these results, I regard the contents of the fills and the proportion of slag in the slag heaps investigated as representative of the Gråfjell area. Except for the sites where specific calculations of fill have been produced, this relative figure is used to suggest the quantity of slag at all sites (Appendix III).

Calculations of Yield

Important in the calculation of volume is archaeometallurgical analysis. The analysis in the Gråfjell project was undertaken by Espelund at NTNU and several researchers at GAL³ (see also Ch. 3, The slag tapping shaft furnace of the Gråfjell area). One of the most important questions here is related to yield. By 'yield' is meant the estimated ratio of iron to slag. The calculation of yield for iron has been undertaken at bloomery sites where both ore and slag samples were included in the metallurgical analyses. The principle is simple in theory, in that one follows individual elements from ore to slag and compares the values. Most important is manganese, as it only derives from bog ore. Other elements such as aluminium and silesium can, however, be introduced from other components such as sand (quartz). For this reason, Espelund based calculations on the manganese scores, and used aluminium and silesium as controls.⁴ GAL used the same method, but in order to test the applicability of the method they also looked at smaller differences in the composition of the slags in order to see whether they influence the yield calculated.⁵ The major critical problem is whether the ore and the slag are fundamentally connected. At bloomery sites, especially ones with extensive production, it is not possible to determine a secure context. However, it is reasonable to assume that the slag that remains within or around the furnaces after the final production can be compared with the remains of ore in the ore stockpiles.

Table 6.2 shows that Espelund based his calculations of yield on 10 kg of slag.⁶ From the ratio between the known components in the ore and the slag, the yield can be calculated. GAL have not included similar figures, but from a

3 NTNU-Norwegian University of Science and Technology, Trondheim; GAL—Geoarchaeological Laboratory, Uppsala, Sweden.

4 Espelund (2003); Espelund and Nordstrand (2003).

5 Grandin et al., (2004), (2005).

6 For a description of the method of calculation, see, for example, Espelund (1991) 55–57.

TABLE 6.2 *Calculations of yield from six bloomery sites. There is a wide discrepancy in the figures, from a minimum yield of 1:0.2 to one of 1:2.3. GAL have not provided figures for iron, ore and slag in their reports*

Calculations of Yield					
Site/context ore—slag	Slag (basis)	Ore	Iron	Yield slag:Iron	Reference
Jfp.1/—Slag concentration	10 kg	34,3 kg	14,05 kg	≈1:1,4	Espelund and Nordstrand 2003
Jfp.1/ Rp.2—SH1	10 kg	20,7 kg	5,6 kg	≈1:0,6	Espelund and Nordstrand 2003
Jfp.39/ore 1 unsorted—SP5	10 kg	25,6 kg	10,28 kg	≈1:1	Espelund 2003
Jfp.39/ore 1 separated—SP5	10 kg	27,3 kg	12,7 kg	≈1:1,2	Espelund 2003
Jfp.39/ore 1 unsorted—SP6	10 kg	40,6 kg	20,1 kg	≈1:2	Espelund 2003
Jfp.39/ore 1 separated—SP6	10 kg	43,3 kg	23,1 kg	≈1:2,3	Espelund 2003
Jfp.5 (two analyses)	—	—	—	1:0,3-1,2	Grandin <i>et al.</i> , 2004
Jfp.7 (two analyses)	—	—	—	1:0,2-0,5	Grandin <i>et al.</i> , 2004
Jfp.8/furnace 2	—	—	—	1:0,2-0,6	Grandin <i>et al.</i> , 2005
Jfp.8/furnace 3	—	—	—	1:0,4-0,7	Grandin <i>et al.</i> , 2005
Jfp.13/furnace 2	—	—	—	1:0,2-0,4	Grandin <i>et al.</i> , 2005

number of samples analysed from the same context, they have given the maximum and minimum yield.

The calculations of yield show that Espelund and GAL reach very different results, with mean values of slag:iron at 1:1.4 and 1:0.5 respectively. Espelund⁷ considers a 1:1 ratio to be a realistic figure. By way of comparison, it may be

⁷ Espelund (2003).

noted that from Sigmund Jakobsen's calculations of yield between slag and iron at Rødsmoen, the ratios 1:0.3, 1:1 and 1:1.5 were used.⁸ Magnusson⁹ has also compared a number of calculations of yield around Europe, and the ratio in most cases falls between 1:0.3 and 1:0.5. The difference in the yield scores fluctuates extensively, and this is a critical problem that is discussed below.

The Volume of Charcoal Production

From the two unemptied charcoal pits, I have discovered that the timber that was to be charred was usually laid below ground level, or below the top of an embankment in the Gråfjell area. Probably one to three log lengths stuck out of the pits (see Ch. 3, Charcoal pits). This contradicts earlier understanding that the amounts of timber above and below ground level were the same.¹⁰ The basis of that view was written accounts from Iceland¹¹ and analyses and experiments which indicated that the shrinkage of the timber, compaction and the use of energy, which altogether are known as the 'shrink effect', was of the order of 40–50%.¹² In unemptied charcoal pits, where charcoal lay up to the ground level or the top of the bank, it was inferred, therefore, that the wood had formed a domed mound above ground level before burning.

This question is crucial in relation to the consumption of wood, but says little about the volume of charcoal that was used in *jernvinna*. The shrink effect is nevertheless important in assessing the actual volume of the pits. The placing of the timber in the pits within the Hedmark tradition was anything but random. The objective was to produce as tight and stable a construction as possible. The boxing, the frame, and the angled logs, all led to little movement during burning so that the carbonized wood largely kept its original form. Only the uppermost layers of logs fragmented. This is related to factors such as the weight of the cover of the kiln, compaction and bubbling, and activity at the kiln during production. Shrinkage did occur, but not leading to fragmentation and inward collapse.

The volume of the timber and the charcoal is given with two measures, the *loose measure*, which is the gross volume of the wood and the voids between the logs, and the *fixed measure*, which is the actual volume of the timber and

8 Jakobsen (1995).

9 Magnusson (1985) 272 with refs.

10 Bloch-Nakkerud (1987) 91; Narmo (1996b) 27–29.

11 Bloch-Nakkerud (1987) 68.

12 Bloch-Nakkerud (1987) 91–92.

subsequently the charcoal.¹³ Loose measure cannot, of course, be used for calculations of volume. Fixed measure is therefore used, as at Hovden, where it was estimated to be two-thirds of the loose measure.¹⁴ This, however, is also a problematic measure, as account needs to be taken of the fact that the volume increases on emptying, as the disturbance aerates the fill (Table 6.3). Considered in relation to the calculation of the level of production, the relative figure is important, as it is the number of litres of charcoal used during iron production that is the important figure. The figures for *fixed measure after removal* are used in the calculations of volume in combination with the formula for a truncated pyramid which provides a spatial description of the charcoal pits.

One challenge in estimating the volume is where the measurements should be taken (see Ch. 3, Charcoal pits). In charcoal pit Jfp.29-3, the charcoal lay up to the top of the embankment while in charcoal pit Jfp.11-6, the fill came only up to the ground level (internal measurement). I have decided to use the internal measurement even though spillage may be a significant source of error. The estimated volume of charcoal is therefore regarded as an absolute minimum in a holistic perspective that contains potential inaccuracies.

The calculations of volume have been undertaken on the basis of the 120 charcoal pits that were investigated by machine. The volume of these charcoal pits varies: the smallest volume is calculated as 2.7 m³ while the largest is fully 22.3 m³ when the figures are given in loose measure. The mean volume is 8.3 m³, and, translated into fixed measure after removal, this gives 12,616 l of charcoal. This figure is regarded as a realistic minimum mean value and is used in the discussion below.

TABLE 6.3 *A calculation using a 0.25 m³ from Jfp.11-6 demonstrates the relationship between loose measure, fixed measure before- and fixed measure after removal*

Jfp.11-6	Litres	Comment
Loose measure	1000	Gross volume of the wood and the voids between the logs
Fixed measure before removal	667	Estimated volume = 2/3 of loose measure
Fixed measure after removal	1520	0,25 m ³ = 380 litres (38 buckets of 10 litres)

¹³ Larsen (1996) 59.

¹⁴ Bloch-Nakkerud (1987) 91.

The Volume of Iron Production

In this section, I shall discuss the volume and yield of all the fully excavated ironmaking sites in comparison with the inferred consumption of charcoal and ore and the probable period of use. The total volume is produced by the mathematical calculation described above. At the sites where the mass and the yield have been calculated, these figures are used. In the other cases, the mean values given will be used. Minimum and maximum values will be given where these have been calculated (see Tab. 6.4). The variables in yield, 1:0.5 and 1:1.4 and the mean of 1:0.9, will be applied to test which agrees best with the charcoal produced.

The consumption of charcoal will be calculated from minimum and maximum values per kilogram of iron for the Evenstad tradition, which are 29.5 and 59.0 l respectively. The same ratios were used in the calculations of volume at Dokkfloy and Rødsmoen,¹⁵ and it is logical to use them here too. It should be noted at this point that the diameter of the shaft of an Evenstad furnace is greater than that of a slag tapping shaft furnace. The consumption of charcoal is thus reckoned to have been greater than in a slag tapping furnace, and the minimum value is therefore most probable.¹⁶ Nevertheless, both figures are applied to look at the range of variation.

In their calculations of yield, GAL have proposed a probable ore:iron ratio of 3:1 at bloomery site Jfp.7.¹⁷ This ratio is uncertain and involves several assumptions. Variables that can affect the quantitative ratio include the type of ore, the quality, and the product desired. But the figure is considered to be a realistic mean value. At Rødsmoen, from ore heap R456, it was calculated that 10 kg of ore could yield 3.2 kg of iron, with a ratio of slag to iron of 1:0.8.¹⁸ The values correspond nicely with GAL's conclusion, and the ratio of 3:1 is used in the calculations.

The quantity of iron that was produced from each smelting is unknown and probably varied. I have chosen to take as a starting point the 19 kg iron bloom that was found beside a hollow way in the Gråfjell area (Fig. 9.1). This comes from a single smelting, but it is not certain that it represents a normal size. Other iron blooms of the Middle Ages are smaller, weighing 4–7 kg. This bloom may initially seem to be relatively large, although from the discussion in Chapter 3, where the method of tapping from a height implies the potential for

15 Narmo (1996a) 146, (1997) 129.

16 Narmo (1996a) 128.

17 Grandin et al. (2004) 29.

18 Narmo 1997:127.

TABLE 6.4 *Volume, yield and consumption of raw material at bloomery sites investigated. Specific yield values are given for sites where they have been calculated. Sites italicized in column 1 were subject to sieving and weighing. At sites where calculations of yield have been made, there are not only maximum and minimum figures but also a calculated mean value for use in the calculation of Sum. Sum—10% is calculated on the basis of the possible margin of error in the calculation of volume using the formula for a half-ellipsoid*

Site	Volume total (m ³)	Total weight (ton)	Slag weight (ton)
<i>Jfp. 1</i>	20,4	39,1	29
Jfp.2	10,1	18,5	11,8
Jfp.3	24,9	49,5	29,3
<i>Jfp.4</i>	4,3	7,8	5,0
Jfp.5	58,1	110,7	68,5
<i>Jfp.6</i>	9,6	15,7	9,8
Jfp.7	1,2	2,0	1,4
Jfp.8	19,2	33,5	21,4
<i>Jfp.9</i>	41,2	80,3	53,4
Jfp.10	8,1	14,8	9,5
Jfp.11	2,8	5,1	3,2
Jfp.12	55,5	102	65,3
Jfp.13	14,4	26,5	16,9
Jfp.14	57,6	111,3	67,6
Jfp.15	7,4	13,6	8,7
<i>Jfp.16</i>	4,2	5,7	2,5
Jfp.17	1,1	2,1	1,3
Jfp.18	<0,1	<0,2	<0,1
Jfp.19	32,5	59,7	38,2
Jfp.20	42,2	77,7	49,5
Jfp.21	6,7	12,3	7,9
Jfp.22	14,6	26,7	17,1
Jfp.23	41,8	76,7	49,0
Jfp.24	10	18,5	11,8
Jfp.25	27,9	51,2	32,8
Jfp.26	32,1	58,9	37,7
Jfp.27	1,3	2,4	1,5
<i>Jfp.28</i>	18,5	34,7	24,4

Produced iron in the ratios of 0,5:1, 0,9:1, og 1,4:1 (tonn)			Number of extractions á 19 kg iron		
0,5:1	0,9:1	1:1,4	0,5:1	0,9:1	1:1,4
	17,4 (0,6:1)/40,6 (1,4:1)			915/2136	
5,9	10,6	16,5	311	558	868
14,7	26,4	41	774	1389	2159
2,5	4,5	7,0	126	237	368
	20,6 (0,3:1)/82,2 (1,2:1)			1084/4326	
4,9	8,8	13,7	295	463	722
	0,3 (0,2:1)/0,7 (0,5:1)		16/37		
	4,3 (0,1:1)/15(0,7:1)			226/789	
26,7	48,1	74,8	3937	2532	3937
4,8	8,6	12,6	253	453	663
1,6	2,9	4,5	84	153	237
32,7	58,8	91,4	1721	3095	4811
	3,4 (0,2:1)/6,8 (0,4:1)			179/358	
33,8	60,1	94,6	1779	3163	4981
4,4	7,8	12,2	231	410	641
1,3	2,3	3,5	68	121	184
0,7	1,2	1,8	37	63	94
<0,05	<0,1	<0,15	<3	<5	<9
19,1	34,4	53,5	1005	1811	2848
24,8	44,6	69,3	1305	2347	3647
4	7,1	11,1	210	374	584
8,6	15,4	23,9	453	811	1258
24,5	44,1	68,6	1290	2321	3610
5,9	10,6	16,5	311	558	869
16,4	29,5	45,9	863	1553	2417
18,9	33,9	52,8	995	1784	2778
0,8	1,4	2,1	42	74	111
12,2	22,0	34,2	640	1158	1800

TABLE 6.4 *Volume, yield and consumption of raw material at bloomery sites investigated. Specific yield values are given for sites where they have been calculated. (cont.)*

Site	Volume total (m ³)	Total weight (ton)	Slag weight (ton)
Jfp.29	24	44	28,1
Jfp.30	132,5	243,4	155,6
Jfp.31	12	22,2	14,1
Jfp.32	37,1	70,5	48,3
Jfp.33	9,4	17,3	11,1
Jfp.34	9,3	16,9	10,9
Jfp.35	0,5	1,0	0,6
Jfp.36	3,0	5,6	3,6
Jfp.37	5,3	9,7	6,2
Jfp.38	2,5	4,6	3,0
Jfp.39	53,6	91,2	61,4
<i>Sum</i>	<i>857,1</i>	<i>1583,6</i>	<i>1017,3</i>
<i>Sum – 10%</i>	<i>771,4</i>	<i>1425,2</i>	<i>915,6</i>

Produced iron in the ratios of 0,5:1, 0,9:1, og 1,4:1 (tonn)			Number of extractions á 19 kg iron		
0,5:1	0,9:1	1:1,4	0,5:1	0,9:1	1:1,4
14,1	25,3	39,3	742	1332	2068
77,8	140,0	217,8	4095	7368	11463
7,0	12,7	19,7	368	668	1036
24,2	43,5	67,6	1274	2290	3558
5,6	10,0	15,5	295	526	816
5,5	9,8	15,3	290	516	805
0,3	0,5	0,8	16	26	42
1,8	3,2	5,0	95	168	263
3,1	5,6	8,7	163	295	458
1,5	2,7	4,2	79	142	221
30,7	55,3	86,0	1616	2911	4526
486,0	897,8	1376,9	28 186	46 450	72 411
437,4	808	1239,2	25 367	41 805	65170

TABLE 6.5 *Volume, yield and consumption of raw material at bloomery sites investigated. Specific yield values are given for sites where they have been calculated. Sites italicized in column 1 were subject to sieving and weighing. At sites where calculations of yield have been made, there are not only maximum and minimum figures but also a calculated mean value for use in the calculation of Sum. Sum—10% is calculated on the basis of the possible margin of error in the calculation of volume using the formula for a half-ellipsoid*

Site	Needed charcoal, in m ³ (min./max.)		
	0,5:1	0,9:1	1:1,4
<i>Jfp.1</i>		513/1027 (0,6:1) / 1197/2395 (1,4:1)	
Jfp.2	174/348	312/625	487/973
Jfp.3	423/867	779/1558	1210/2419
<i>Jfp.4</i>	74/148	133/266	207/413
Jfp.5		608/1215 (0,3:1)/2424/4850 (1,2:1)	
<i>Jfp.6</i>	142/330	260/519	404/808
Jfp.7		9/18 (0,2:1) / 21/41 (1,2:1)	
Jfp.8		127/254 (0,1:1) / 443/885 (0,7:1)	
<i>Jfp.9</i>	774/1575	1419/2838	2207/4413
Jfp.10	142/283	254/507	372/743
Jfp.11	47/94	86/171	133/266
Jfp.12	965/1929	1735/3469	2696/5393
Jfp.13		100/201 (0,2:1) / 201/401 (0,4:1)	
Jfp.14	997/1994	1773/3546	2791/5581
Jfp.15	130/260	230/460	360/720
<i>Jfp.16</i>	38/77	68/136	103/207
Jfp.17	21/41	35/70	53/106
Jfp.18	<1,5/3	<3/6	<5/9
Jfp.19	564/1127	1014/2030	1578/3157
Jfp.20	731/1463	1316/2631	2044/4089
Jfp.21	118/236	210/419	328/655
Jfp.22	254/507	454/909	705/1410
Jfp.23	723/1446	1301/2602	2024/4047
Jfp.24	174/348	313/625	487/974
Jfp.25	484/968	870/1740	1354/2708
Jfp.26	558/1115	1000/2000	1558/3115
Jfp.27	24/47	41/83	124/281
<i>Jfp.28</i>	360/720	649/1310	1010/2018
Jfp.29	416/832	746/1493	1159/2319

Needed ore, in ton (min./max)

0,5:1	0,9:1	1:1,4
	52,2/121,8	
17,7	31,8	49,5
44,1	79,2	123
7,5	13,5	21
	61,8/246,6	
14,7	26,4	41,1
	0,9/2,1	
	12,9/45	
80,1	144,3	224
14,4	25,8	37,8
4,8	8,7	13,5
98,1	176,4	274
	10,2/20,4	
101,4	180,3	283,8
13,2	23,4	36,6
3,9	6,9	10,5
2,1	3,6	5,4
<0,15	<0,3	<0,45
57,3	103,2	160,5
74,4	133,8	208
12	21,3	33,3
25,8	46,2	71,7
73,5	132,3	205,8
17,7	31,8	49,5
49,2	88,5	137,7
56,7	101,7	158,4
2,4	4,2	6,3
36,6	66	102,6
42,3	75,9	117,9

TABLE 6.5 *Volume, yield and consumption of raw material at bloomery sites investigated. (cont.)*

Site	Needed charcoal, in m ³ (min./max.)		
	0,51	0,91	1,14
Jfp.30	2295/4590	4130/8260	6425/12850
Jfp.31	207/414	375/750	581/1162
Jfp.32	714/1428	1283/2567	1994/3988
Jfp.33	165/330	295/590	457/914
Jfp.34	162/325	289/578	451/903
Jfp.35	9/18	15/30	24/48
Jfp.36	53/106	94/189	148/295
Jfp.37	92/183	165/330	257/513
Jfp.38	44/88	78/159	124/248
Jfp.39	906/1811	1631/3263	2537/5074
Sum	14 339/28 766	26 178/52 344	40 683/81 391
Sum - 10%	12 905/25 889	23 560/47 110	36 615/73 252

Needed ore, in ton (min./max)		
0,5:1	0,9:1	1:1,4
233,4	420	653,4
21	38,1	59,1
72,6	130,5	202,8
16,8	30,0	46,5
16,5	29,4	45,9
0,9	1,5	2,4
5,4	9,6	15
9,3	16,8	26,1
4,5	8,1	12,6
92,1	165,9	258,0
1460,6	2662,3	4129,8
1314,4	2396,1	3716,8

extended working, it could also be viewed as a normal product. Therefore, 19 kg is used as the starting point in calculating the number of smeltings.

Table 6.5 shows great variation in both the yield and the consumption of ore and charcoal. The iron produced at Jfp.1, for instance, from the given outer values, will range between 17.4 and 40.6 t. The yield has been calculated from the volume of the slag heaps, which is determined as 20.4 m³, and a slag weight of 1 m³ which was set, above, at 1,175 kg. At the same site, the suggested consumption of charcoal ranges from 174 m³ to 973 m³, and the need for ore from 17.7 to 49.5 t. Jfp.30, which is the largest site excavated, is calculated to have produced from 77.8 to 217.8 t of iron. At Jfp.35, by contrast, only 300–800 kg of iron were produced. The lowest production, however, was at Jfp.18, with <50–150 kg of iron. Importantly, this site is the only one in the Gråfjell area dated to the Merovingian Period (Ch. 3, The slag tapping furnace of the Gråfjell area—a distinct method; see Ch. 8, The Hedmark tradition in time and space). It was probably not the only one of its type, but its size and its dating to a period in which settlement in this area was limited may indicate that the ironmaking at this site was only meant for local needs.

The Consumption of Raw Materials and Yield

The agreement in the consumption of raw materials and yield can be tested at sites where the number of charcoal pits appears to be known. This is the case with several production sites, of which I shall focus on two, both of which are relatively isolated, Jfp.17 and Jfp.31, where there are 1 and 11 charcoal pits respectively. I also bring Jfp.20 into the discussion because of its massive size (see Tab. 6.4/6.5).

At Jfp.17, the volume of charcoal is considered to be certain, but only a sample of the charcoal pits at Jfp.31 were dug by machine. The volume is calculated from actual figures from the charcoal pits sections and the mean value (8.3 m³ = 12,616 l) for the remainder. The mean value is also used to give a necessary consumption of charcoal at Jfp.30. At Jfp.17, I assume that production took place in only one season and I assume also that the fill of one charcoal pit was likewise the minimum required for one season.¹⁹

The consumption of ore can be deduced both from the iron yield and the charcoal produced. In the Gråfjell area, is it only roasting site Rp.18 of those that have been excavated that is believed to have remained untouched after the roasting. The weight of the ore, at 652 kg, represents one roasting fire. If we

19 See Narmo (1996a).

look at the quantity of ore from the mean figure for production from one charcoal pit (approx. $8.3 \text{ m}^3/12,616 \text{ l}$), the need for ore would be 1.3–2.5 t (29.5–59 l of charcoal per kilogram of iron). Therefore, around 3 roasting fires of the size of Rp.18 appear to have been needed to use up the charcoal from an average charcoal pit.

At bloomery site Jfp.17, the calculations of yield indicate that from 0.7 to 1.8 t of iron were produced. The charcoal produced in charcoal pit Jfp.17-1 is just 21,000 l. Only when the lowest yield and the minimum consumption of charcoal apply is there a good agreement in the level of production. For any other calculations, the need for charcoal is much greater than the quantity of charcoal demonstrably produced. The smallest discrepancy between charcoal production and need is 14,000 l, while the largest is fully 85,000 l (Tab. 6.6).

Charcoal pit Jfp.17-1 has a volume of as much as 14.1 m^3 , higher than the mean value. This may be connected to intended production from a given quantity of ore. If we turn the probability around and use the charcoal produced as the starting point, the minimum consumption of charcoal gives 726 kg of iron. The ore needed would then be more than 2 t. Roasting place Rp.2 lay immediately alongside the site and is interpreted, in this context, as the site of production. Immediately alongside the roasting place was another layer of ore that is interpreted as an interim storage site as there are no signs of roasting. The interim storage site indicates that roasting took place more than once. To meet the need for ore, a roasting of 652 kg must have taken place around three times.

In the case of Jfp.31, the calculations are more difficult to interpret, as the need for charcoal at a minimum level of consumption also lies far above the estimated output of the 11 charcoal pits. The discrepancy is fully 55,000 l, corresponding to four 'standard' charcoal burnings. Jfp.31 is one of the sites at the greatest distance from its nearest neighbour, and the charcoal pits in the area have to be regarded as the source for all of its production. In this light, the discrepancy could be explained by various factors:

- The calculated yield is too high.
- Charcoal was produced in pits that have not been identified.
- Several charcoal pits had more than one phase of use.
- Charcoal production was greater than calculated.
- The ratio of charcoal to iron is too high.
- The estimated volume of the slag heaps is too high.

Which factors are the source of the error is difficult to determine, but excavations are unlikely to reveal all the phases of use, so there is an uncertainty there. A combination of two or more of the factors above also seems likely.

TABLE 6.6 *Three ironmaking sites with calculated iron output and their associated charcoal pits with the calculated volume of production, together with the assumed need for charcoal and ore according to calculations of yield. The charcoal production at Jfp.30 is calculated from the mean value for the volume of machine-dug pits. At Jfp.31, the same factor is used after the angled line*

Site	Produced iron (ton) (0,5:1-0,9:1-1,4:1)	Number of charcoal pits	Volume charcoal pits (m ³)	Produced charcoal in fixed measure after removal (litres)	Needed charcoal (1000 litres) (0,5:1-0,9:1-1,4:1)	Needed ore (ton) (0,5:1-0,9:1-1,4:1)
Jfp.17	0,7-1,2-1,8	1	14,1	21 432	21/41-35/ 70-53/106	2,1-3,6-5,4
Jfp.30	77,8-140-217,8	100-150	830-1245	1 231 200- 1 892 400	2295/4590-4130/ 8260-6425/ 12850	233,4-420- 653,4
Jfp.31	7,0-12,7-19,7	11	99,6	122 664/ 147 440	207/414-375/ 750-581/1162	21-38-59,1

There is a similar tendency at Jfp.30. With a yield of 0.5 kg of iron per kilogram of slag, the need for charcoal at minimum consumption would have been 2.3 million litres. Around the site are 100-150 charcoal pits that can be associated with the site, and the charcoal produced is calculated at 1.2-1.9 million litres. With a yield of 0.9 kg of iron, the need for charcoal would have been just under 4.1 million litres. If, by contrast, we apply a yield of 1.4 kg of iron, the difference between the inferred output and the need (10 million litres) becomes ridiculously large.

The calculations of yield show that if one calculates using a ratio of slag to iron at 1:1.4, with the maximum consumption of charcoal, there is *no* agreement between the need for charcoal and the production demonstrated. The volume at the sites investigated required 4,283 charcoal burnings of 8.3 m³. By contrast, 755 charcoal pits would cover the need at the minimum levels of yield and consumption of charcoal. About one in three of the sites recorded in the Gråfjell area have been included in the calculations of yield. From 1,745 recorded charcoal pits, of which I reckon that at least 20% were used twice or more, the number of charcoal burnings must lie around 2,100. With the minimum yield, there is a need for 2,265 charcoal burnings. The difference is 165 (7.8%), which I regard as satisfactory.

All the same, that the yield has to be put at 1:0.5 is a source of doubt, as a number of factors may be involved. In Denmark and Sweden figures between 1:0.2 and 1:0.5 are used.²⁰ What is certain is that the yield cannot have been 1:1.4. The ratio 1:0.9 also appears too high. Taking sources of error that exist in all of the points discussed into account, I believe that the yield after smelting should lie somewhere between 0.5 and 0.9 kg of iron per kilogram of slag. When the total yield from the production is to be calculated, I have therefore decided to use a *slag:iron ratio of 1:0.7*.

Volume and Period of Use

At Jfp.17, it is assumed that the production was that of a single season. By setting the yield at 1:0.7, the production comes to 800 kg of iron. This corresponds to 42 smeltings with an iron ingot of 19 kg. How high daily production was is difficult to say for certain. Narmo has suggested that at Dokkfloy three tapplings of 19.3 kg of slag could be achieved each day, giving 17.4 kg of iron (yield 1:0.3).²¹ The largest tapping cone found in the Gråfjell area (Jfp.9) alone weighs more than 60 kg. This slag must be treated as coming from a single smelting, and is here treated as the highest minimum output per day. The quantity of slag produced is thus almost the same as at Dokkfloy. Around 60 kg of slag corresponds to a daily output of 42 kg of iron, and to the removal of around two blooms per day. At Jfp.17, this corresponds to a period of use of 22 days (at a ratio of 1:0.7). From the number of charcoal pits and smeltings, the activity at Jfp.31 must have taken place over at least 12 seasons (one charcoal pit is used twice), with an annual period of use of 20 working days. In the case of Jfp.30, the number of annual working days is 17 (108.9 t over 150 years/charcoal pits). It is questionable whether 17–22 days of work per year is a credible figure. This cannot be tested directly, but ¹⁴C dates can assist with exploring the issue.

The suggested duration of production is only partially reflected in the date ranges (see Chapter 5, on chronological models). From Figure 6.3, the conclusion may be drawn that production at Jfp.17 can be assigned to the thirteenth century. The end point most probably lies between AD 1250 and AD 1275. A dendrochronological sample from the furnace has been dated to post-AD 1266, which confirms the inference. Jfp.30 has ¹⁴C dates that spread over several centuries. The start point is elusive because the model is bimodal. If one accepts that the mode around AD 1100 is the most probable start point, the activity is

20 Englund (2002) 288–291; pers. comm. Olfert Voss: 1:0.2.

21 Narmo (1996a) 140–144.

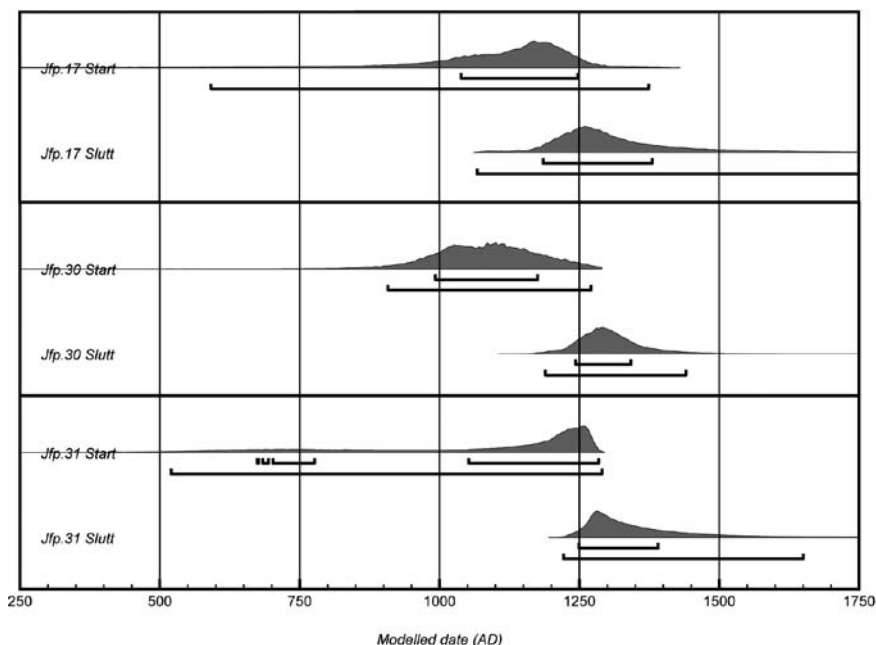


FIGURE 6.3 *Modelled date ranges with start and end dates for activity at Jfp.17, Jfp.30 and Jfp.31.*
 OXCAL V4.1.4 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER
 ET AL (2009)

restricted to less than 200 years. At the same time, the ^{14}C dates indicate that there may have been minor hiatuses in the work. The site consists of two pairs of parallel slag heaps, interpreted as two production zones. The long period, therefore, need not reflect activity that continued over several centuries. The annual output must then have been greater at Jfp.30, although we cannot fix its exact volume. A modelling of the activity at Jfp.31 indicates that all of the activity very probably took place between AD 1250 and AD 1275. In this light, a production period of 12 years is not improbable. However, the discrepancy between the iron produced and the charcoal produced has to be taken into account as well. The estimate made above introduces a hypothesis of greater charcoal output per pit than the proposed average. If one assumes that charcoal was produced more than once in several of the pits, annual production may in fact have been lower but have continued for a longer period. Nonetheless, at Jfp.31 too, the question of whether this was the case has to be asked. Although it cannot be demonstrated, I am of the view that annual production must have been greater than what would correspond to a single charcoal pit. The organization of this large-scale production in total, implies that the goal was production for export, which must be linked to external demand. In purely logical terms, it would therefore be rational to have had greater annual production

when the team was on the job. I have already pointed out that production was moved according to the resources. When the best wood had been used up, work ceased and new sites were established. In this way, there is little purpose in carrying out relatively non-intensive work. From the estimated period of 22 days of smelting, in addition to the time that cutting wood, burning charcoal, collecting ore and roasting requires, it is quite possible to double the annual output. This is supported by the conclusion that work was undertaken in two furnaces at the same time. No definite answer can be produced, but I would accept that the activity at Jfp.31 did not extend beyond 6–8 seasons, and that the work at Jfp.30 probably extended over 25–50 years. The modelled date ranges do not give anything like such unambiguous results, but a longer sequence of activity at Jfp.30 is likely given the level of production.

The Volume of Iron from the Hedmark Tradition

Several attempts have been made to determine how much iron was produced by the Hedmark tradition. Narmo has weighed and sieved the slag heaps at Rødsmoen, and his figures have to stand as rock-steady. For this reason, I have taken his figures as secure in the discussion of methods for calculations of volume. Altogether, 6 slag heaps of the Hedmark tradition's type have been included.²² The slag heap at R305 has two phases, but this does not matter in the present context as I aim to determine the total volume from the bloomery sites. On average this gives a quantity of 18 t of slag, and with a ratio of slag to iron of 1:0.7 this yields 12.6 t of iron. In her thesis on *jernvinna* in Vang, Furnes and Løten communities, Bårdseng²³ has produced calculations of volume at the bloomery sites (see Ch. 4, Hedemarken). Bårdseng also used Narmo's basic figures from bloomery site R695 in her calculations. She generated an average production of 24 t per site.

A critical point to raise against Bårdseng's calculations of volume is that she refers to an approximate correspondence between R695 and the mean figure from the slag heaps that are included in the analysis. The volume of the slag heaps based upon the survey measurements, worked out with the formula for a half-ellipsoid, gives figures of 20.5 and 18.1 m³. It should be noted at this point that the volume in Table 6.1 is much higher, because there, measurements from excavation have been used. Here, I have decided to use the survey measurements just as Bårdseng did. The mean volume of the slag heaps in her analyses, however, is 8.8 m³. This constitutes a difference of no less than 46%. By using

²² Narmo (1997) 129, Fig. 77.

²³ Bårdseng (1998) 79–80.

Bårdseng's mean, and a ratio of slag to iron of 1:0.7, plus a reduction of 10%, I get to an average output of 13 t of iron at a site with 2 slag heaps and 5 t of iron from sites with a single slag heap.

In the course of her studies at Torsby in Värmland, Svensson²⁴ produced a calculation of the volume of production from ironmaking (see also Ch. 4.5). At these sites, she came to an average output of 22.4 t. She does not explain directly what method she used, but does note that account was taken of a range of uncertainties.

I have produced calculations of mass according to the formula for an ellipsoid for all 92 surveyed sites in the Gråfjell area and for four sites at Rødsmoen. The total volume is 1,838 m³ when the error-margin of 10% explained above has been deducted. The total mass is therefore estimated to have been 3,776 t and the slag content 2,408 t. With a yield of 0.7, this gives 1,686 tonnes of iron produced. Further analyses as based upon these figures, and I apply the average production is a factor to all other bloomery sites in the region. The total yield divided over 96 bloomery sites gives an average production of 17.6 t of iron.

The extent of the Gråfjell area in which ironmaking took place was around 90 km², which produces an average density of 1.3 bloomeries per km². The picture is more complex, as some areas had a very high density and others more limited production. Generally, the density is not very high compared with, for instance, Møsstrand and Hovden, but it is important to note that the number of sites is not to be equated to the volume, as the level of production at individual sites varies hugely. From the known distribution, I believe that the density of sites is consistent within the boundaries of the Hedmark tradition. The Outlying Surveys show that in some places there was very intensive production while other areas have a lower density. Some areas show no production, but these usually lie at the outer edge of the range of the tradition, for instance, in Rendalen and Kongsvinger.

The defined boundaries of the Hedmark tradition contain an area of around 11,400 km². Large areas of land were not suited to ironmaking, such as Hedmarksvidda, the mountain areas of Rendal and Trysilfjell, and the farming land along the Glomma. This accounts for 25–30% of the whole area. Several places are also too hilly and rocky for any substantial production. This is also the case in the Gråfjell area, but this type of landscape occurs somewhat more frequently in the south, and the extent of production was probably somewhat less here. I regard unproductive land as making up around 50% of the total, and the

24 Svensson (1998) 98–101.

productive area is therefore about 5,700 km². The volume of production can thus be estimated as having been around 130,000 t. At present, there are around 600 known bloomery sites that I have assigned to the Hedmark tradition. Only smaller parts of the area have been surveyed, and from the known density I assume that the figure should be very much higher.

The Volume of Production through Time

If the figure is evenly distributed across a period of 350 years, the Gråfjell area saw 400 t of iron produced annually. This cannot be correct, however, as extraction varied over time (see Ch. 5, The Gråfjell area—a specific chronology). In Table 5.5 the activity is distributed over 50-year periods. This shows that the number of active sites was, for example, 20 times greater in the period AD 1200–1250 than in the period AD 950–1000. Production itself, however, was not necessarily 20 times greater, as the period of use at several of the sites extends across a number of 50-year periods. In Figure 6.4, the measurable production based on the period of use of the sites is shown. The volume of production is evenly distributed within the 50-year cycles on the basis of Table 5.5. For example, the activity at Jfp.2 is dated within the period AD 1150–1300. The

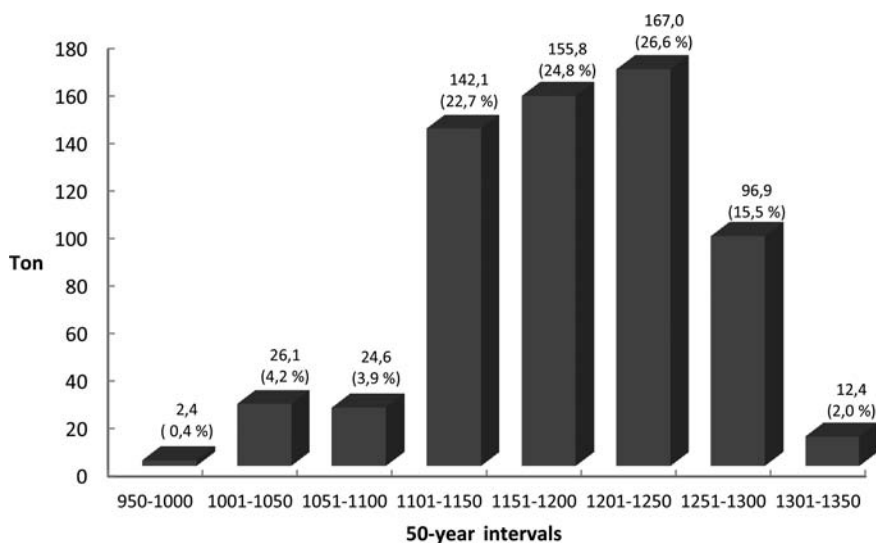


FIGURE 6.4 Iron extraction through time in the Gråfjell area on the basis of 28 bloomery sites. The period of use of the individual sites is calculated in Figure 5.13 and Table 5.5.

inferred production is 8.3 t. This means an average output of 2.8 t per 50 years. Several bloomery sites have a start or end point that falls in the middle of a 50-year period. In these cases, a further distribution of the volume of production is introduced. A weakness in this calculation is again that the period of use is too long. All the same, the distribution gives us a good view of the volume of production through time.

Production was clearly at its greatest in the period AD 1101–1250 (74%). As Table 5.5 shows, there were also eight more sites at work in AD 1201–1250 than in AD 1101–1150 (40%). This difference is not clearly reflected in the volume of production, however, which is only 4% more. The reason is that several of the large bloomery sites are dated to the twelfth century, and many production sites of smaller capacity are dated to the thirteenth century. An interpretative problem is the relationship between the periods AD 1001–1050 and 1051–1100, with production being a fraction higher in the earlier period. In my view, it is the ¹⁴C dates themselves that are the problem in this case. It would be logical to see a gradual increase in production rather than what this diagram shows. In all probability it is the relationship between AD 1051–1100 and 1101–1150 that is misleading. The reason is the calibration curve, which is problematic for the period in question (Fig. 6.5). A flattening and regression in the calibration curve means that small discrepancies distort the date ranges. The result is that the period AD 1051–1100 is under-represented while the following period, AD 1101–1150, and 1151–1200 to some degree, are over-represented. The jump in production between AD 1051–1100 and 1101–1150 can largely be explained in this way, and a steadier rise is probable.

The result from the Gråfjell area cannot be transposed directly to the region as a whole because the start point changes from south to north. However, I consider it reasonable that the figures do not vary greatly in the case of much of the region. It is probably in the south that variation is greatest, but even though there was an earlier start point here, many ¹⁴C dates fall within the period of greatest intensity. The end point for the activity varies less, with the exception of *Region_Värmland*, and its abandonment in the Gråfjell area corresponds closely with the region as a whole. In *Region_South* and *Region_Våler*, one has nevertheless to reckon with a greater decline in the period AD 1200–1250 as the activity appears to come to an end just before AD 1250. For the region as a whole, I believe that the Gråfjell area is plausibly typical, with the exceptions noted.

The extent of iron production, as I deduce it, was enormous. From the discussion in Chapter 1.7, it is clear that the volume exceeds what other studies have concluded. For this reason, it will now be crucial to try to place the

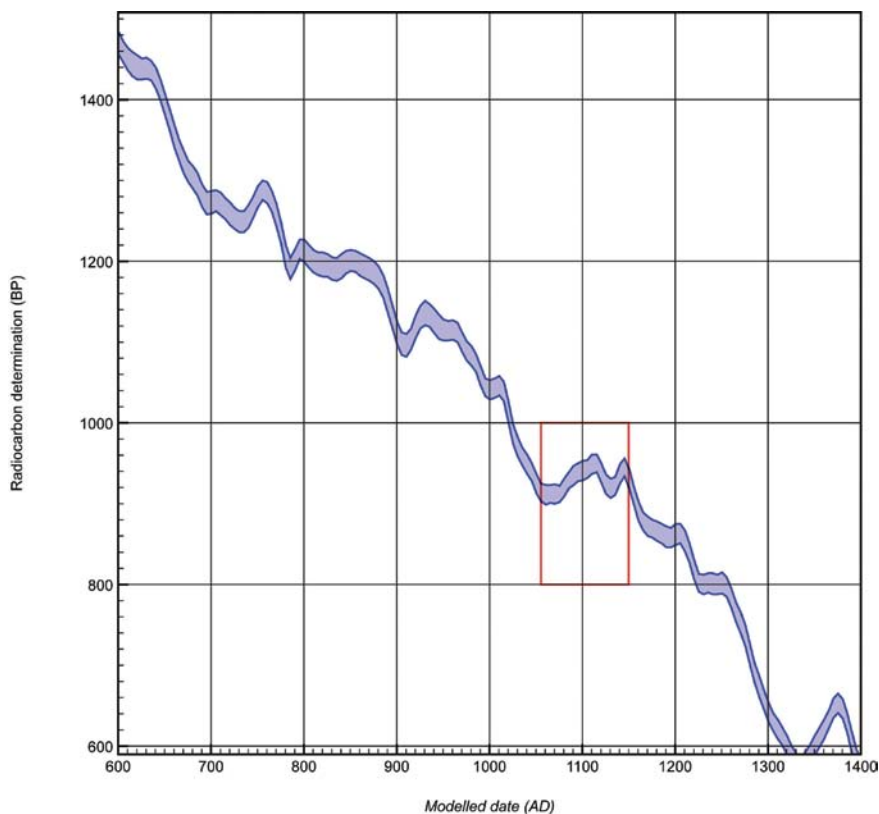


FIGURE 6.5 *The calibration curve IntCal09 for the period AD 600–1400 (Reimer et al., 2009). The period AD 1050–1150 is difficult to date, and even small differences move the dates forward in time. AD 1050–1100 is under-represented and AD 1100–1150 is over-represented in bulk evidence.*

OXCAL V4.1.4 BRONK RAMSEY (2010); R:5 ATMOSPHERIC DATA FROM REIMER ET AL (2009)

Hedmark tradition in a wider social, economic and political context. What was the basis of the ironmaking and how did it function as a factor in society, such as it was in the Viking Period and Middle Ages? In order to try to answer these questions, I shall now consider what other sources tell us about the region at this time.

The Study Area in the Light of Archaeological and Historical Sources

Up to this point, the focus has been on the ironmaking evidence from the Gråfjell area and Hedmark County. The overall objective, however, is to reveal the social importance of *jernvinna*, not just within this region but also in a broader context. For this, it is necessary to consider the relevant archaeological and historical sources. Settlement, the use of the outlying land, and written sources are particularly significant in this context.

Settlement and Its Development

The study area is illuminated by several local and regional studies which deal with the settlement context on the basis of archaeological evidence: especially finds and burials. These works have mostly been published in local historical series and periodicals, and usually by local historians. Archaeologists and historians have contributed to an extent. A common character of the studies is that a place or an area is placed in its historical context, and details such as farm- and place-names, finds and ancient monuments, provide a foundation for ideas about the settlement pattern of the Iron Age and Middle Ages.

Many of these works are quite old, and there are new finds in several of the municipalities. Of recent works, it is first and foremost Bergstøl's¹ review of the finds from the northern administrative districts of Østerdalen and south to Elverum that is relevant. We have no equivalent studies from Solør, and there may have been new finds that are not noted here. Although this is potentially a weakness, Bergstøl's studies of Østerdalen show that more recent finds have not affected the pattern of distribution, which I think would be the case in Solør too. In the case of Hedemarken, there are also several works from recent years that have focused on the settlement and political history of the area.

Stor-Elvdal and Rendalen

In the northern districts of Stor-Elvdal and Rendalen, there is a clear break in the material found from the Early Iron Age. The local historical synopses

¹ Bergstøl (2008).

describe Stor-Elvdal as void of finds in the Early Iron Age, and there are no farm-names securely assigned to the period either.² More recently, three finds have appeared with a possible date from the Early Iron Age or the transition to the Late Iron Age.³ Rendalen produces a quite different picture, however, also in comparison to the southern districts, with several finds from the end of the Early Iron Age. In Sølendalen, a burial dated to the pre-Roman Iron Age has been excavated.⁴ This grave is markedly older than the other finds from the river valleys.⁵ Brøgger⁶ assumed that parts of Rendalen were cleared in the 5th–6th centuries, and from artefact typology he believed that it was groups from Trøndelag or Central Sweden who settled there and lived by livestock farming and hunting. He also pointed out that some farm-names testify to settlement in the sixth century. Apart from the mountain grave of the pre-Roman Iron Age, however, there are no finds that can definitely be dated before the end of the Migration Period, but Bergstøl⁷ believes that the first agrarian settlement most probably started in this period. The burial in Sølendalen, in his opinion, bears witness to earlier settlement in the mountains, probably of nomadic hunters.

Finds from the Late Iron Age in Stor-Elvdal are also scarce. An axe and a celt are dated to the seventh century, and the artefacts are otherwise from the Viking Period and Middle Ages.⁸ The artefacts are for the most part stray finds of arrowheads, together with a few weapon graves.⁹ There is more evidence from Rendalen: eight finds are dated to the Merovingian Period and a number of finds and graves are from the Viking Period and Middle Ages.¹⁰

The extent of settlement in Stor-Elvdal in the Late Iron Age is unclear, but from the farm-names it is thought that a dozen or so farms were cleared in the Viking Period.¹¹ Within the geographical bounds of the Hedmark tradition, there is only one farm that appears in a written record before AD 1350. This is Berg at *Kaupangr*,¹² which is referred to in three royal letters of the 13th and 14th centuries. The local historian Steinar Sørensen's¹³ studies of abandoned

2 Fosvold (1936) 21; Hveberg (1949) 8.

3 Bergstøl (2008) 62.

4 Skjølsvold (1981).

5 Bergstøl (2008) 92–95.

6 Brøgger (1942).

7 Bergstøl (2008) 103.

8 Bergstøl (2008) 63.

9 Fosvold (1936) 21–26.

10 Bergstøl (2008) 96–100.

11 Hveberg (1949) 8.

12 Today named Koppang.

13 Sørensen (1981) 68.

farms in Rendalen and Stor-Elvdal illuminate the development of settlement in the area. In Stor-Elvdal, he found that 32 farms were cleared before 1350. What proportion of these go back to the Iron Age is not discussed. In Rendalen too, a number of farms were founded in the Viking Period.¹⁴ But unlike before, colonization then spread in from the south.¹⁵ Sørensen¹⁶ concludes that 60 farms were cleared by 1350. Settlement was thus more extensive in Rendalen than in Stor-Elvdal, a point that is corroborated by the finds of objects and graves.

Trysil

There are only a few stray finds from the Iron Age in Trysil. There is a belt-stone and an arrowhead from the Migration Period. A rich grave of the Merovingian Period was found in Eltdalen. The archaeological evidence otherwise dates to the Viking Period and Middle Ages. Along the main broad valley few finds have been made. Ljørdalen, on the other hand, is especially rich in finds. All of these are stray finds, and many of those are from the farms, suggesting permanent settlement. The finds comprise weapons and tools. A number of hunting arrowheads have been found from this period too.¹⁷ From the farm of Vestby Søndre there are reports of a stone cairn that contained a stone cist with burnt bone dated to the Viking Period. This is an area of rich outlying land, well suited to hunting and fishing. Several bloomery sites have also been recorded around Vestby.¹⁸ The number of grave sites is relatively low. Several graves have been recorded which are believed to be associable with Saami culture. A grave mound has also been recorded in Ljørdalen, while in the main valley there are two cairn fields that are probably clearance cairns.¹⁹ The local historian Eyvind Lillevold²⁰ thinks that the relationship between the resources of the outlying land and burial cairns testifies to the fact that these were the sources of wealth that were critical for the community, rather than the meagre agriculture of the Trysil valley.

Apart from the archaeological finds which point to unbroken use, there are no farms which can confidently be identified as having roots back in the Iron Age. Along the Trysil River, there are a few farms with names that go back to the Late Iron Age, and around AD 1050 there were at least seven or eight farms

14 Hveberg (1949) 7.

15 Brøgger (1942); Narmo (2000) 105.

16 Sørensen (1981) 67.

17 Lillevold (1977) 43–47; Bergstøl (2008) 119–121.

18 Lunde (1977).

19 Bergstøl (2008) 121–122.

20 Lillevold (1977) 55.

in the valley. In the Middle Ages, further clearance was undertaken, but, unlike in Stor-Elvdal and Rendalen, the number of farms is indeterminate. The expansion is not considered to have been major, however.²¹ The finds indicate that there had been other forms of settlement in this district. Hunting appears to have been a leading activity, and, as in Rendalen, it is probable that nomadic groups were exploiting the mountain and valley areas.

Åmot

No stray finds of the Early Iron Age had been made in Åmot until recently.²² Through the excavations along the River Rena, however, an iron adze was found,²³ radiocarbon-dated to AD 80–260 (1835 ± 35 BP). The adze was found at a site where surface-retouched arrowheads and a mace head, together with cooking pits and fireplaces, point to activity from the Late Bronze Age to the Merovingian Period.²⁴ A great increase in the volume of finds sets in with the Viking Period, and burial mounds have been identified in several places.²⁵ Several of the grave finds are rich, with weapon graves predominating. Sørensen²⁶ states that the majority are from the end of the ninth century to around the year 1000.

The history of settlement in Åmot has been explored in a number of studies, but the conclusions vary. There are no farm-names dated earlier than the seventh century.²⁷ Despite the absence of farm-names and objects, the finds by the River Rena and the 14C dates of bloomery sites²⁸ and cooking pits²⁹ in the Gråfjell area show that there was activity in the forests and valleys here in the pre-Roman and Roman Iron Age which would normally be associated with an agrarian culture. The bloomery site is situated near Løsset Nordseter and it is reasonable to believe that the shieling was the basis for this production. This is supported by two cooking pits that were found immediately alongside the shieling, one of which is dated to the Roman Iron Age (AD 220–315) and the other to the Migration Period (AD 535–595). A pollen analysis also reveals that there was a thinning of the forest, and signs of pasture below the old ground

21 Lillevold (1977) 57–58.

22 Hveberg (1949) 8; Bergstøl (2008) 55.

23 Damlien (2010) 415.

24 Damlien (2010) 447.

25 Brøgger (1942); Hveberg (1949) 8; Sørensen (1979) 76–81; Bergstøl (2008) 55–59.

26 Sørensen (1979) 87–89.

27 Hveberg (1949) 8; Sørensen (1979) 82.

28 Risbøl et al. (2002b) 53.

29 Bergstøl (1997) 61; Rundberget (2007) 109; Amundsen (2007) 57–61.

surface of a Migration Period pit have been found. Tina Amundsen³⁰ is of the opinion that the area remained in use between those two dates. The bloomery site has a period of use just in between the two cooking pit phases, and I consider it probable that there was activity here in parts of the Early Iron Age. During the excavation of bloomery site Jfp.10, which is situated immediately alongside the shieling site of Deset Østseter, another cooking pit was found, which was dated to 390–255 BC. Another cooking pit has been recorded here, but it is not dated. These traces also point, in my view, to activity other than hunting alone.

Starting in the Late Iron Age, more extensive settlement got under way. Lillevold³¹ states that 34 farms had been cleared in Åmot by around the year 1000 and that only two further farms were cleared in the Middle Ages. He attributes this stagnation to the marginal and poor conditions. The toponymist Margit Harsson³² states that 43 ‘matriculated’ farms³³ derive from before the Black Death, of which around 30 were cleared before the end of the Viking Period. Narmo³⁴ believes that eight or nine farms were cleared in the Merovingian Period, 5 in the ninth century, 13 or 14 in the tenth century, and 13 or 14 in the Middle Ages.

The studies indicate a great expansion of settlement in the Viking Period and somewhat less clearance in the Middle Ages. Sørensen has also made a study of the named farms in Åmot. He deduces that the number of working farms in 1350 was 72, half of which had been cleared in the Middle Ages. This suggests a consistent growth from the Late Iron Age through the Middle Ages to 1350. The great differences in numbers in these studies are due to the fact that Narmo and Harsson looked only at matriculated farms while Sørensen has also included holdings that he believes were separated before 1350. He reckons on 44 ‘named farms’³⁵ and 28 subdivided holdings, which were mostly created in the Middle Ages (Fig. 7.1).³⁶ The plateau that Narmo and Harsson suggest is thus rather misleading. The growth of settlement was, conversely, steady from the end of the Iron Age through to the first half of the fourteenth century.

30 Amundsen (2007) 61.

31 Lillevold (1973) 106–107.

32 Harsson (1996).

33 Farms registered with a farm-number in a survey of the 1880s.

34 Narmo (2000) 113–114.

35 Farms with historical names, which may now be divided into multiple holdings.

36 Sørensen (1999) 96.

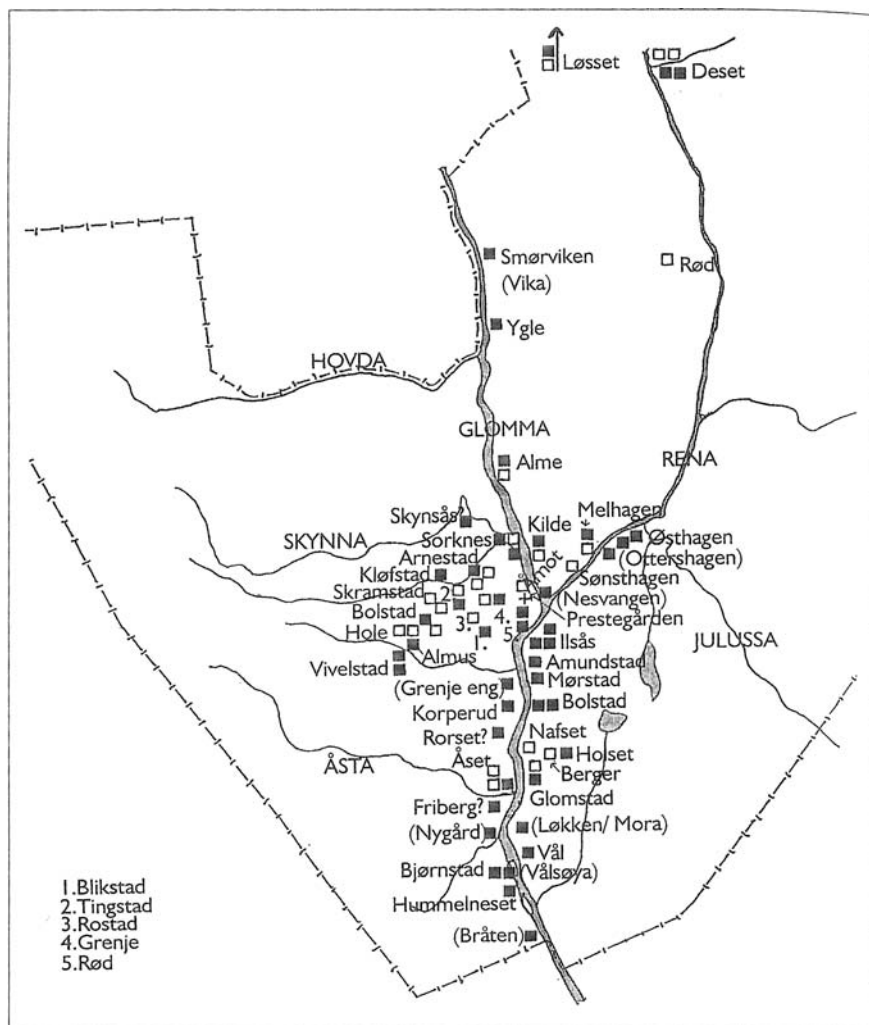


FIGURE 7.1 *Settlement in Åmot in the High Middle Ages*

OPEN SQUARE = SETTLED AFTER THE BLACK DEATH; BLACK SQUARE = FARM ABANDONED AFTER THE BLACK DEATH; ?=UNCERTAIN POSITION; AND ()=MODERN FARM-NAME, AFTER SØRENSEN (1999) 78.

The settlement studies above are based solely on normal farming, and Narmo³⁷ has rightly emphasized that one should allow for forms of settlement based on other economic strategies. If farm- and place-names alone are used, these forms of settlement will not be uncovered. Harsson³⁸ has also been through

37 Narmo (2000) 127.

38 Harsson (2000) 9.

the place-names in the Gråfjell area without finding evidence of permanent settlement before the Black Death. At the edge of the area, however, there are two pre-Conversion farms: Deset and Løsset. This picture has now changed.³⁹ Apart from the cooking pits and bloomery sites noted, five shieling sites have 14C dates from the Merovingian Period to the Middle Ages. At Rødseter, a permanent settlement was founded in the Middle Ages and perhaps as early as the Late Iron Age,⁴⁰ while Melgårdsetra at Deset Østseter has appeared to be a shieling of the same period. The three other shieling sites, Kjølsetra, Knubblia and Styggdalsseter, have not been excavated, and the earliest use is probably unknown. A pollen sample from Deisjøen points to pasturing back in the Late Iron Age.⁴¹ There is also Løsset Nordseter, already referred to.

The shieling site of Stavlia was investigated as part of the Rødsmo Project.⁴² Radiocarbon dates from a possible building and hearths show that the site was in use in the Viking Period and Middle Ages. This is confirmed by evidence of pasturing from a pollen sample from a nearby bog. Whether Stavlia was originally a farm or a shieling is not known.

The field terraces at Rødsmoen are the remains of a form of farming that differed from usual agriculture. This type of ancient monument has been argued over, but is regarded to be man-made.⁴³ There are scattered 14C dates, and one reduced terrace had a period of use from the Merovingian/Viking Period to the fourteenth century.⁴⁴ Similar terraces have also been identified, for instance in the Gråfjell area, Atneoset, Elverum and Alvdal,⁴⁵ and they are regarded as having been a normal form of land-division in this valley. Who was responsible for this form of farming is not determined, but both hunting societies⁴⁶ and people from the agricultural communities on Hedemarken⁴⁷ have been suggested.

The knowledge that has been gained through the major investigations in Åmot is crucial to the whole study area. In particular, I consider that traces of settlement of marginal or non-agrarian character are very important for an understanding of the structure of society. I do not consider this form of settlement to have been unique to Åmot, but rather that settlement may be found in non-agrarian zones across the whole area of investigation.

39 Risbøl et al. (2002b); Amundsen (2007) 139.

40 Stene (in press [2014]).

41 Solem (2003) 27.

42 Bergstøl (1997) 27–33.

43 Holm Sørensen (1997) 8–11.

44 Bergstøl (1997) 79–80.

45 Amundsen (2011) 281.

46 Bergstøl (2008); Narmo (2000).

47 Amundsen (2011).

This corresponds well with the results from a recent study at the shieling of Gåla, west of the Glomma River in Stor-Elvdal. A pollen-sequence from a nearby bog shows that grazing was already taking place in the Pre-Roman Iron Age, and that there has been continuous use of pasture ever since. Near the shieling, three iron bloomeries have been identified, two of which are typologically dated to the Early Iron Age and the third to the Middle Ages. There are also several hunting systems nearby. Not far away, close to another shieling, Northern Messelt, a large bloomery site of the same type has been located. As at Gåla and Nordre Løsset, it is reasonable to suppose that Messelt was settled or seasonally occupied far back in the Early Iron Age.

Elverum

From Elverum, there are three objects that might date from the Early Iron Age. All of them, however, could equally be from the early Merovingian Period.⁴⁸ A few farms also have names which could derive from as early as the sixth or seventh century,⁴⁹ amongst which *Alfareimr*⁵⁰ could have been an early central farmstead. There is also a small amount of material from the Merovingian Period, but the quantity increases from the Viking Period, when place-names also testify to extensive new clearance.⁵¹

There are a large number of burial mounds in Elverum. Settlement, burials and finds show that Heradsbygda, Hernes and the modern administrative centre were three central places in the Viking Period (Fig. 7.2).⁵² However, there are also other areas with signs of activity. At Grundset, there is a large field of clearance cairns that has been examined by Ingunn Holm.⁵³ The cultivation layers from the cairns produce ¹⁴C dates from the Migration Period to the Middle Ages. A sediment core also shows clear cultural impact starting in the Migration Period. Field terraces have also been identified in several places.

Solør

The northernmost municipality in Solør, Våler, is poorest in finds, and also has the smallest number of named farms of the Early Iron Age and Middle

48 Østmo (2000) 33; Bergstøl (2008) 37–38.

49 Hagen (1958) 51; Sørensen (1979); Østmo (2000) 35–36.

50 Meaning 'the elves' farm' = today's Elverum.

51 Hagen (1958) 52–63; Østmo (2000) 38–53.

52 Hagen (1958) 63–65; Sørensen (1979) 67–76; Østmo (2000) 53–55; Bergstøl (2008) 40.

53 Holm (2004).

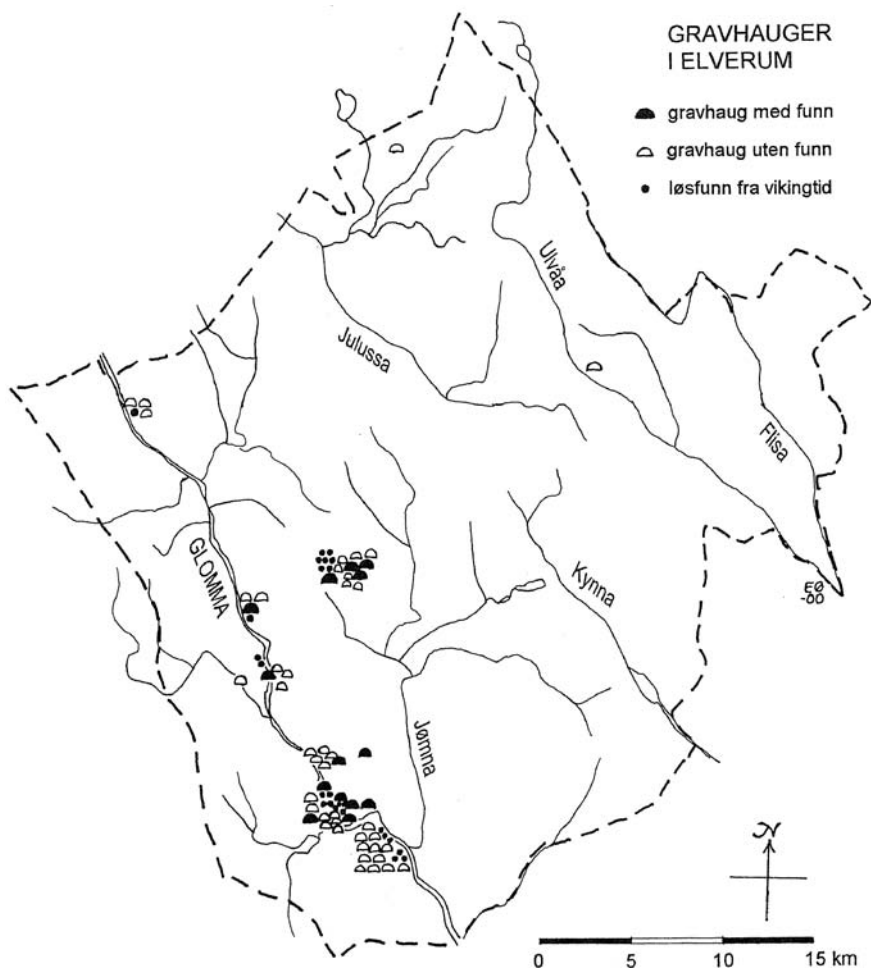


FIGURE 7.2 *Burial mounds in Elverum, approximate distribution and quantity. The distribution shows the centre of activity of settlement in the Viking Period*

FILLED HALF CIRCLE = WITH FINDS, EMPTY HALF CIRCLE = WITHOUT FINDS, DOTS = STRAY FINDS, AFTER ØSTMO (2000) 41, FIG. 20.

Ages. The local historian Harald Hveberg⁵⁴ considers that about 25 farms were cleared in the Iron Age and a further 30 were established before AD 1350.

There are no finds from the Early Iron Age. Two farms could have origins in the sixth century.⁵⁵ Ingunn Holm⁵⁶ asserts that a cemetery east of Braskreidfoss

⁵⁴ Hveberg (1972) 25.

⁵⁵ Bugge (1973) 3.

⁵⁶ Holm (2002) 45.

was already being used in the Early Iron Age. A pollen core taken from Glesmyr by the River Glomma has evidence for pasturing from the Bronze Age onwards.

From the end of the seventh century, a minor wave of colonization began in Våler,⁵⁷ which increased in the Viking Period. The farms mostly lie on the eastern side of the River Glomma. The naming tradition of the Viking Period agrees very closely with the southern settled districts of Solør and to some extent with Värmland, a detail that points to a contact zone and immigration from the south and east.⁵⁸ There are a few finds from the Viking Period, of which a hoard of 60 iron bars from Lillehaugen⁵⁹ is noteworthy in the present context. There are only four definite grave mounds, although several have been removed in the good agricultural land along the River Glomma.⁶⁰

The central administrative districts of Solør, Åsnes and Grue, are richer in finds than Våler, while the number of farm-names indicates a considerably higher population in pre-modern times. However, there are few remains from the Early Iron Age here too. An arrowhead dated to the fourth century and another from the end of the Early Iron Age, both from Kongshaug in Grue, together with a belt-stone from Hof, are the only finds.⁶¹ From the farm-names, the earliest clearance is thought to go back to the sixth century in Grue, Hof and Åsnes. The local historian Magne Mortensson⁶² links the earliest settlement, which he believes to date from the Viking Period, to the know-how for making iron and the tools required. The earliest farms were, however, cleared long before the Viking Period, and the iron was not of itself a precondition for clearing. Nonetheless, Mortensson does have a point when he postulates that the iron was a key factor for clearance close to the forests. As I shall discuss in due course, it can thus appear that it was indeed ironmaking that was determinative and which motivated the colonization and clearance of further areas.

The earliest farms in Solør were cleared from the best agricultural lands, such as Heradsmarka, where the farms Kongshov and Huseby show where the chieftain of Solør resided (Fig. 7.3).⁶³ Further evidence of Early Iron Age settlement is a pollen core from Rennmyra in Åsnes, with evidence of pasturing in the period AD 5–145.⁶⁴

57 Hveberg (1949) 18.

58 Bugge (1973) 3–5.

59 Brøgger (1942) 24.

60 Holm (2002) 30.

61 Brøgger (1942) 20; Hveberg (1948) 39, (1949) 13–18.

62 Mortensson (1976) 121–124.

63 Hveberg (1949) 24.

64 Holm (2002) 51.

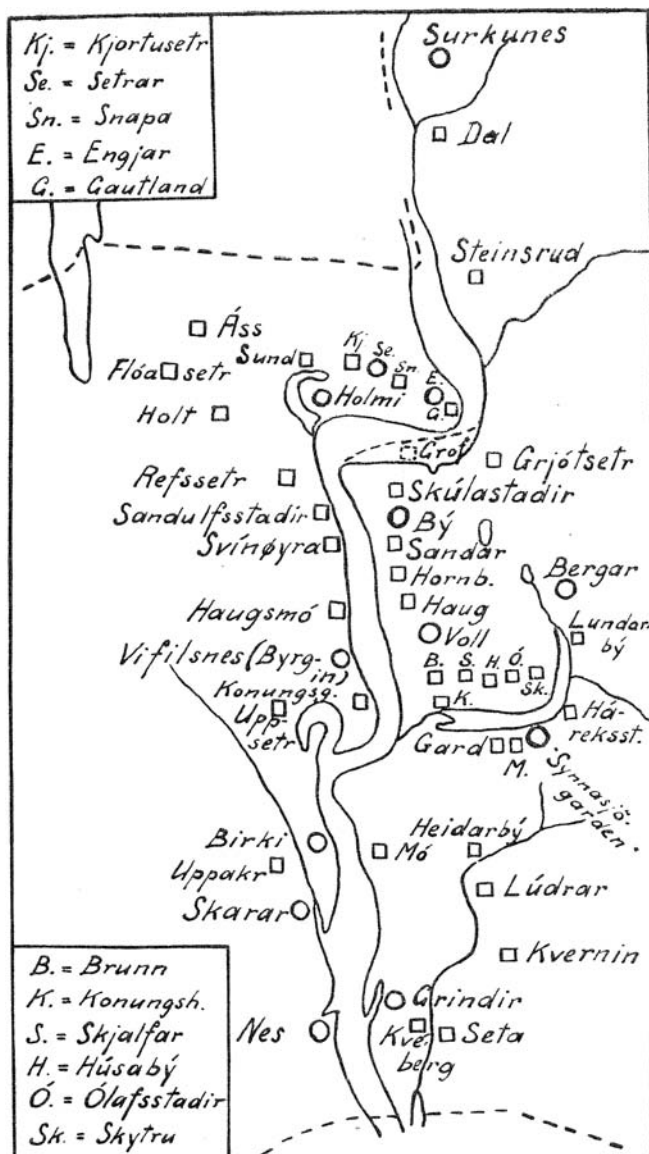


FIGURE 7.3 Settlement in Grue around AD 1050

RING = FARMS FROM THE EARLY IRON AGE TO THE VIKING PERIOD;
 SQUARE = FARMS OF THE VIKING PERIOD, AFTER HVEBERG (1948) 83.

Harald Hveberg has studied the named farms and place-names in Solør. In Åsnes, he reckons on 25 farms having been cleared in the Late Iron Age and 30 in the Middle Ages before the Black Death. In Grue and Hof, 14 or 15 farms were founded before the Viking Period, while around 40–50 new holdings were cleared during that period.⁶⁵ Several sites have produced collections of cooking stones associated with the farms. Development continued in the Middle Ages, with 40–50 more farms being cleared up to 1350. Altogether, he concludes that there were about 100 holdings distributed across 75 matriculated farms in Grue and Hof in the fourteenth century.

From the Viking Period there are also some 40–50 grave finds from the area, most of them in Grue and Hof, the majority of which are weapon graves.⁶⁶ There are currently few known burial mounds: one in Åsnes and six sites in Grue.⁶⁷ The wealth of finds, and the chieftain's seats, together with named cult centres and thing sites, show us a strong and vital chieftaincy with a centre in Grue and Hof from the seventh century and throughout the Viking Period.

In the southernmost part of the area, Kongsvinger and Eidskog, there are also farms which must be considered to go back to the Late Roman Period or Migration Period. This is the case both in Vinger and in Brandval. From the former, there is a fourth-century arrowhead.⁶⁸ The farms in both places lie right beside the River Glomma, and their position probably implies that they were contemporary centres. Hveberg⁶⁹ reckons on 40–50 farms having been cleared in Brandval from the Merovingian Period and into the Viking Period, and 30 more being founded in the Middle Ages. In Kongsvinger and Eidskog, the figures are 30 and 37 respectively in the Late Iron Age, and 55 and 45 in the Middle Ages.

There is one Viking Period grave find in Kongsvinger, and also 18 known burial mounds, while there is only one find in Eidskog, and it is uncertain.⁷⁰

Hedemarken

The settlement history of Hedemarken is markedly different from that of Østerdalen. Large parts of the landscape were cleared and extensive agriculture was practised there throughout the Iron Age. Pollen series from Hedemarken show that there had been continuous pasturing and cultivation since the Bronze

65 Hveberg (1948) 80–92, (1972) 28–29.

66 Hveberg (1948) 66–75, (1949) 20.

67 Holm (2002) 30.

68 Hveberg (1949) 13.

69 Hveberg (1972) 30–32.

70 Holm (2002) 30.

Age.⁷¹ Lars Pilø also points out that from the Bronze Age onwards there was a growth in population density right through to the Viking Period.⁷² The number of farms that derive from the Iron Age here is much higher than in Østerdalen.

On Hedemarken, two centres stand out: the major farm of Åker and the trading site of Hamar. Åker stands out as the most important chieftain's seat from the end of the Late Iron Age to the end of the Viking Period.⁷³ Åker is thought to have been the *thing* site for Opplandene, and the royal seat for the national monarchy early in the medieval period. The place-names around Åker also testify to the status of the site as a religious centre.⁷⁴ As a power centre, Åker probably controlled resources and distribution from forest, mountain and agricultural areas, and participated in regional and super-regional trade networks.

In the Middle Ages, Hamar was an important administrative centre, and the trading site there was a central node for merchants and craftsmen.⁷⁵ From its position on the Mjøsa, it was a natural choice, both as a *thing* site and as a trade centre where surpluses from farming and resources of outlying land could be exchanged. The Hamar Chronicle,⁷⁶ which portrays life in Hamar before 1537, tells of a lively town with merchants and craftsmen, settlement and administrative business. Here are mentioned, for instance, several specialist smiths, such as locksmiths, blacksmiths, knife makers and goldsmiths.⁷⁷ The archaeological evidence, on the other hand, provides different information. The topographical data largely agrees, but otherwise there is little of this activity to be seen. There is indeed a lot of material associated with metalworking, but this is mostly coppersmithing.⁷⁸ Quite a lot of coins have been found too. Settlement and courtyards have not been identified on any large scale, and the settlement was probably scattered and rural in character.

The historian Tor Sæther⁷⁹ consequently regards the Hamar Chronicle as misleading, and probably written with a belief in a former golden age that had been lost. The trading site, he believes, was rather an annual event at which visitors exchanged goods. The age of the trading site is uncertain. Agricultural

71 Høeg (1996) 131; Pilø (2002).

72 Pilø (2002) 140.

73 Hagen (1979); Rolfsen (1992b); Hernæs (1989); Sæther (1989); Bårdseng (1998) 91–92; Pilø (2002).

74 Sæther (1994) 10.

75 Sæther (1989), (1994), (2011).

76 Written post-1554, writer unknown.

77 Sandvold (1985) 95.

78 Sæther (1989) 16–17; 2011.

79 Sæther (1989) 18–19.

layers have dates to the Late Iron Age but the artefactual evidence comes primarily from the eleventh century.⁸⁰ The trading site is therefore considered to go back to the first half or the middle of the eleventh century.⁸¹ Sæther considers that trade at this site was controlled by the royal centre at Åker in the earlier Middle Ages.⁸² The reason why this business took place at the cathedral peninsula at Hamar and not in the creek at Åker was, in his view, the conditions for harbouring and defence. Åker is sited in an area that was far from peaceful in the Viking Period and Middle Ages. He does not consider the area to have been subordinated to the national monarchy before the reign of Harald Hardråde. Åker then became a royal estate, and the trading site with its trade network and resources became an element in the royal administration. Sæther emphasizes the iron that was transported from Gausdal and Østerdalen, as the most important economic foundation. Line Bårdseng⁸³ also regards the iron as a key factor for Åker and the trading site of Hamar, and *jernvinna* has to be counted as a factor of both economic and political power.

The key place of the trading site in the kingdom is reflected, *inter alia*, by Harald Hardråde having coins minted in Hamar around 1060.⁸⁴ In the 12th and 13th centuries, Opplandene was riddled with civil strife, and it is repeatedly recorded that both the king and his men, or usurpers, sat and reigned in Hamar. The trading site of Hamar appears as an ever-more important component in a system of control over Opplandene throughout this period, while Åker seems gradually to lose its central role. Control of trade and networks appears to me to have been an important motive. After 1240, however, Hamar is not particularly mentioned except in ecclesiastical contexts, and its importance to the king is reduced after the kingdom had been consolidated. One reason may be that the king no longer saw it as necessary to be personally close to Hamar after the rebellions had been suppressed.⁸⁵ However, I find it remarkable that just when control over this node had finally been established by the Crown, it would appear that the king let it go and handed its government over to the Church—especially when trade and the exchange of goods, and thus important income, were themselves the foundation stone of the centre.

The reason why the royal power let go of the trading site of Hamar can be seen in connection with the foundation of the episcopal see in 1152. In unsettled

80 Sæther (1989); Pedersen (2000).

81 Bårdseng (1998) 101.

82 Sæther (1989) 25.

83 Bårdseng (1998) 105.

84 Sæther (1994) 12.

85 Sæther (1989) 33–34.

times, the Church stood out as a pacifying element, and it quickly grew into a significant landowner and power-broker. There was probably a political game between the Church and the Crown. An example of this is that the old royal farm at Åker had become an episcopal estate by the Reformation. It is not clear when that took place, but it is possible that the farm was included as a payment when the king took over Helgøya in 1237.⁸⁶ When and how the Church assumed control of the trading site is unclear. Sæther picks out a papal letter of 1234 which indicates that the bishop then had the right of ownership of Hamar. He also points to the fact that Stavanger was given to the Church, with its taxes and tolls, which may also have happened at Hamar.⁸⁷ Around the year 1250, in any event, there was only one royal officer in Hamar, and the Church had by then certainly taken over control of the business. This is confirmed by the Hamar Chronicle, which only refers to merchants and craftsmen in the service of the Church at this date. What the consequences of this transference of the trading site at Hamar were is not known, and in that light it is far from certain that the king really gave up control of the resources and trading business in and out of the area. There were several concurrent trading networks and nodes, including trading sites in Østerdalen, which I shall discuss further shortly.

Concluding Remarks

As this survey shows, the development of settlement throughout the study area was varied. On Hedemarken, there was a continuous increase in density from as early as the Bronze Age, and both the chieftainly and royal central place of Åker and the trading site at Hamar testify to an important and extensive activity up to and into the Middle Ages. Apart from in Upper Rendalen, the evidence from Østerdalen and Solør otherwise points to little agrarian settlement before the seventh century. Settlement of the Early Iron Age in Rendalen is believed to have its roots in immigration from the north or east and thus is separate from the later colonization from the south. In Solør, there was earlier and more extensive clearance than in Østerdalen, where clearance seems to have been very limited before the last phase of the Late Iron Age. In the Viking Period and Middle Ages, by contrast, it appears that the whole region saw the same development of settlement, and studies of farm-names show that growth was probably steady until the Black Death.

This picture is constructed on the basis of archaeological finds and place-name studies. More recent research, especially on agriculture, shows, however,

86 Sæther (1989); see Kolsrud (1911) 5.

87 Sæther (1989) 34; see Blom (1967) 104.

that it is a little lacking in nuance. Several pollen cores have evidence for pasture of earlier origin. The field terraces are earlier too, although from their date and their position they are associated with a form of cultivation that was used by groups who relied primarily upon hunting.⁸⁸ Hilde Amundsen,⁸⁹ on the other hand, is of the view that the traces of pasturing and cultivation, together with cooking pits, bloomery sites and hunting pits, represent the wider activity and settlement area of an agrarian population rather than a hunting one. She thus differs from the majority view in suggesting that in Østerdalen there was small-scale settlement associated with a farming society as far back as the Bronze Age.

I support this view. One piece of evidence that I think may be linked to early agrarian settlement is the bloomery sites of the Østland type from the Early Iron Age. Bergstøl⁹⁰ refers to the bloomery site found by survey work in the Gråfjell area and discusses two views. One is the idea of cultural dualism,⁹¹ where a hunting population took up ironmaking as an element of their economy. He rejects this idea, and rather explains ironmaking as an aspect of the agrarian settlement of Hedemarken. In other words, people travelled all the way up to the inhospitable and steep slopes of Åmot to make iron, a journey of very many miles. There are more bloomeries of this type recorded in Åmot and Stor-Elvdal, and there are several in Elverum, especially in the areas around Heradsbygda. This type of site is largely found in forests close to farmland or shielings. The production is thus considered to have been a form of ironmaking that was linked to the economy of the Iron Age farm. I do not believe that such long journeys would have been made to produce iron when the resources were also available right on their doorstep on Hedemarken. In terms of positioning, it is also of interest that the bloomery sites in the Gråfjell area and in Stor-Elvdal are located right beside shielings. The cooking pits of the pre-Roman and Roman Iron Age at Løsset Nordseter are also linked to shielings. I consider it overwhelmingly likely as a result that there were settlements in Østerdalen closely associated with the Iron Age population of Hedemarken earlier than the archaeological evidence has yet revealed.

Settlement or settlement-related traces in Åmot also show that conventional farming was not the only method of subsistence; rather that this was settlement using forest and pasture as key resources. The extent of this settlement

88 Narmo (2000); Bergstøl (1997), (2008).

89 Amundsen (2011) 279–283.

90 Bergstøl (2008) 190.

91 Johansen (1973).

has not been established, but I feel certain that it was spread over the whole study area.

Hunting

A lot of activities have gone on in the forest areas in all periods. There are many visible remains left by different activities, but these are overwhelmingly from more recent times. Nonetheless, several types of ancient monument have dates back in the Middle Ages or earlier. In the previous section I pointed out the shieling zones, fields of clearance cairns and field terraces that are also found in typically woodland environments. Despite their context, these types of ancient monument are closely associated with settlement of some form. It is logical to include this evidence in the current study. I shall now look at the second major category of ancient monuments found in the woodland areas: hunting pits and hunting sites.⁹² The principal objective of this review is to see how hunting, which was a major undertaking at times, is correlated with ironmaking chronologically and spatially; i.e. whether the activities were contemporary, or if one superseded the other, and what the driving forces behind such development were.

Stor-Elvdal, Rendalen and Trysil

The two most northerly administrative districts in the region differ from one another. In Rendalen, there had been both elk hunting and large-scale reindeer hunting. Parts of Rendalen consist of relatively high mountain ranges, which are the grazing area for the reindeer. In the great forest of Stor-Elvdal and further south, it is only the elk that could thrive. In Rendalen, there are major reindeer hunting sites which are understood as fitting into a high-level, governed structure. They seem to have been most intensively used in the Viking Period and Middle Ages.⁹³ There were probably hunting pits for both elk and reindeer in the same system, but elk hunting is thought to have been secondary.⁹⁴ In Stor-Elvdal, many elk hunting sites have been recorded. These hunting sites date from the Bronze Age through to the sixteenth century.⁹⁵ In Trysil,

92 The term 'hunting sites' refers to large or smaller systems of hunting pits which mainly lie in a line.

93 Bergstøl (2008) 100–101.

94 Mathiesen (2004).

95 Barth (1981) 296.

Lunde⁹⁶ recorded and mapped a series of hunting sites and separate hunting pits in the 1950s. At present, 164 separate pits are known, all of them for elk, although Bergstøl⁹⁷ believes that the number is much higher. The artefactual finds from Trysil include many arrowheads, and hunting is understood to have been an important economic activity.

Åmot and Elverum

Through both the Rødsmo Project and the Gråfjell Project, a number of hunting pits and hunting sites were investigated in Åmot. The 14C dates from Rødsmoen run from the Neolithic to the Late Iron Age, and the earliest are considered to be uncertain. Several samples securely date the pits to as early as the Early Iron Age, and the sites appear to have gone out of use at the transition to the Late Iron Age.⁹⁸ Several of the hunting pits were reused for charcoal-making in the Middle Ages.

The picture is a not quite the same in the Gråfjell area. A number of 14C dates have been taken, and the earliest phase appears to go back to AD 600, just when the hunting pits at Rødsmoen went out of use. There was then a reduction around the year 1000, before a new phase of use appears in the thirteenth century which carried on into the seventeenth century.⁹⁹ In Elverum too, a number of hunting systems dated to the Late Roman Period and Migration Period have been recorded, and these went out of use at the end of the Early Iron Age.¹⁰⁰

Hedemarken and Solør

Many hunting pits are known on Hedemarken and Solør. The great majority of these are for elk, but there are also sites for reindeer hunting in Ringsaker. One hunting trap in Ringsaker has been excavated and dated to the Bronze Age.¹⁰¹ Apart from that, only two hunting pits in Stange have been investigated, one of which is dated to the pre-Roman Iron Age.¹⁰²

In Solør, by far the highest number is in Åsnes, and the fewest in Våler. Apart from that, the numbers appear to be quite even.¹⁰³ One hunting pit in

96 Lunde (1977).

97 Bergstøl (2008) 121.

98 Bergstøl (1997) 58.

99 Amundsen (2007) 128–129.

100 Mikkelsen (1986); Bergstøl (2008) 41.

101 Gustafson (2007) 166–167.

102 Pers. comm. Lil Gustafson, 10 January 2012.

103 Holm (2004) 32–33.

Eidskog, which dates to the Bronze Age, has been excavated.¹⁰⁴ Several hunting pits have been examined in Värmland. These are radiocarbon-dated back to the Neolithic, but the evidence was taken from the ancient ground surface beneath the banks and thus is very uncertain.¹⁰⁵

Concluding Remarks

Hunting pits have been identified in relatively large numbers throughout the region. In the mountain areas reindeer were hunted, while elk is naturally predominant in the lower-lying forest areas. The hunting was separated into several levels, from isolated hunting traps to very extensive systems. The variation, as Bergstøl points out, testifies to different economic motives. Individual hunting traps are relatively easy to operate and maintain, while the larger systems clearly needed greater organization. The smaller hunting arrangements could thus be operated by a few people and be features of a family's or a group's economy. On the other hand, the large-scale hunting systems, for which the work of a number of people was coordinated, were rooted in a specialized economic system involving trade and exchange of goods. Meat, leather and hides were readily tradable goods, and a society with the means to manage a large-scale hunting organization could profit nicely thereby.

Major systems for both reindeer and elk hunting are found throughout the region. The surveys reveal differences in the number of hunting pits from district to district. Large areas have not been surveyed, and the number of hunting pits and hunting systems was much greater than the picture we have at the moment. This shows that the herds of reindeer and elk were large, and it must be supposed that several groups or communities were involved in trapping using pits as an important element of their economies.

The period of use is also varied. There are ¹⁴C dates back as far as the Neolithic and up to the end of the Middle Ages. There is some question, however, about the earliest ¹⁴C dates from the context of the samples.¹⁰⁶ Over the greater part of the region, the activity appears most intense in the Early Iron Age. The dating evidence we have is, however, full of lacunae, except on Rødsmoen and in the Gråfjell area, where many ¹⁴C dates have been taken from a number of hunting pits. In most cases we have only single ¹⁴C dates from individual pits. We therefore do not know if all phases of use have been identified. All the same, the ¹⁴C dates form a picture in which the Early Iron Age stands out as the most intensive period within the study area. The knowledge we have gained

¹⁰⁴ Bloch-Nakkerud (1989).

¹⁰⁵ Svensson (1998) 75.

¹⁰⁶ Svensson (1995); Holm (2004); Amundsen (2007); Gustafson (2007); Bergstøl (2008).

so far also implies that the hunting sites largely went out of use in the sixth century.¹⁰⁷ From the Merovingian and Viking Periods there are several stray finds of arrows, which may indicate that the bow and arrow took over as the method of hunting. Bergstøl looks to crisis and decline on the Continent, or to a possible change in whoever was controlling the hunting grounds, followed by a change in hunting methods.

There are divergences from this picture. In the northern mountain region of Rendalen, reindeer hunting took place on a massive scale in the Viking Period and Middle Ages. Bergstøl interprets this intensive reindeer hunting as presupposing the establishment of some all-encompassing organization. The extent of the hunting exceeds the capacity of the settlement, and so other agents must have been involved in the activity. Hunting in Rendalen must thus be seen as analogous to ironmaking in Østerdalen. The course of development is approximately the same as that which the Hedmark tradition reveals, and its extent was much greater than the demand and the settlement imply it should have been. For this reason, hunting, just like *jernvinna*, must be viewed as an economic activity of importance to the royal authority in the Middle Ages.¹⁰⁸

The dates from the Gråfjell area produce a different picture, chronologically. Hunting sites are not identified earlier than the Late Iron Age and the activity appears to be relatively limited. There is then a decline or cessation in the activity around the year 1000. It reappears in the thirteenth century, and the most intensive hunting was in the fifteenth century.

Apart from the intensive reindeer hunting in the mountains of Rendalen, it therefore does not appear that hunting was undertaken using hunting systems in the period this study is concerned with. This is corroborated by analyses of burnt bone from hearths at the bloomery sites. Not a single elk bone has been found here. There are a few fragments of beaver, fox and hare, but, these apart, domesticates are quite predominant. The finds of small game indicate that there was some hunting and fishing, and elk hunting was probably a part of this, but not as a dominant subsistence basis.

The reason for this dynamic change in the exploitation of resources is probably to be found in the colonization of the Late Iron Age. This makes the question of which group or groups were using the region before the great colonization a central one. The conventional view has been that it was established groups depending primarily on hunting who were here before the farming society started to exploit the area to a greater extent.¹⁰⁹ It was also these

107 Bergstøl (2008) 185–186.

108 See also Stene (2014).

109 Brøgger (1942); Narmo (2000); Bergstøl (1997), (2008).

groups which cultivated the field terraces. However, as I revealed in the previous section, there are new ideas which accept that a settlement with its roots in an agrarian society can be traced back to the centuries BC. The archaeologist Hilde Amundsen¹¹⁰ believes that they can be placed even further back in time. Through her study of the stone finds in this area, she concludes that from the Late Neolithic and Bronze Age a differentiation into two traditions was under way, with specialization in agriculture on Hedemarken and specialization in hunting in Engerdal. Østerdalen appears in this view as a contact zone in which both agriculture and the hunting culture made use of accessible resources. Amundsen also sees a clear boundary with the material of the South Saami hunting culture along the River Trysil, while Rendalen is perceived as a boundary area. I shall discuss this in more detail in Chapter 8, albeit with a focus on the Iron Age and Middle Ages.

The Written Sources

Introduction

Historical sources dealing with ironmaking in the Middle Ages are extremely scarce. Iron in one form or another is, however, referred to in various places, and this is particularly the case in laws, decrees, charters and price controls. The literature on this topic has been collated and discussed in several works.¹¹¹ The sources have especially been made use of in regional studies. But the evidence is limited, and I have consequently also looked at other written sources which may contribute more indirectly to a deeper understanding of the Hedmark tradition.

There are two reasons for introducing the written sources. The first is that the archaeological evidence demonstrates that *jernvinna* was undoubtedly of enormous extent. A question which then arises is how this is reflected in the written sources. The second reason is that it is essential to see if the written sources can indirectly provide insights into the political, economic and social circumstances of production. Methodically, this has involved the review and study of the primary sources, which are for the most part letters, decrees and legal texts, but without attempting to produce my own translations. Primary sources and historical names are therefore usually cited in modern Norwegian forms below. My interpretations are thus based upon on earlier historical

110 Amundsen (2011) 285.

111 Olafsen (1916); Blom (1991).

discussions, the view and conclusions of the authors of which are brought into the discussion.

Saga Literature

The earliest information about the study area appears in *Ynglingetal*¹¹² and *Ynglinge saga*¹¹³ in *Heimskringla*.¹¹⁴ These provide an account of Olaf Tree-feller, who was a Swedish king of the Yngling dynasty. According to these sagas, this Olaf fled from Svealand when his father Ingjald Ill-Ruler was slain by the Swedes. He cleared and took control of the areas along the river that debouches into Lake Vänern, the River Klarälv in Värmland. He personally took part in the clearance work and thus gained the nickname Tree-feller. Olaf became king of Värmland and married Solveig, the daughter of King Halfdan Gold-tooth of Solør, in what is supposed to be the first contact between the Yngling dynasty and Norway. Solveig was descended from Solvi the Old, who was responsible for the clearing of Solør. Olaf is treated in many contexts as the first Norwegian king of the Yngling dynasty. However, he never ruled in Norway and in this respect the idea is mistaken.¹¹⁵

The truth about Olaf Tree-feller is unclear, but it is agreed that he was a historical figure and a minor king who through his genealogy linked Sweden and Norway. It is disputed, however, whether Olaf really was of the Yngling line. Krag¹¹⁶ maintains Olaf was put into the Yngling dynasty in order to link the Norwegian kings to them. He bases this on the fact that *Y.t.* was not written until several centuries after the supposed events took place, and that one objective was to associate the Norwegian royal line with the Uppsala kingdom. Krag similarly believes that the association that Olaf's successors gained with Vestfold was written in for the same reason. This conclusion, however, has been rejected, for instance by Dagfinn Skre,¹¹⁷ who believes that *Y.t.* has a tenth-century origin. He argues that it was the kings of Vestfold who wished to link themselves with Opplandene and so with the Uppsala dynasty through Harald Fairhair. Skre thus sees a clear conjunction between the political elite in Vestfold and Opplandene and Birka and the Mälar region. This contact zone was also identified by the archaeologist Charlotte Blindheim,¹¹⁸ and she

¹¹² *Y.t.*

¹¹³ *Y.saga.*

¹¹⁴ *Hkr.*

¹¹⁵ Krag (1991) 202.

¹¹⁶ Krag (1991) 163.

¹¹⁷ Skre (2007) 414–426.

¹¹⁸ Blindheim (1984) 53–55.

considered that the parallels in the finds confirm what the saga claims about the Uppland kings gaining control of parts of Opplandene and Viken. Blindheim also considered Solør to have been a link zone, amongst other things in the trading traffic between Skiringsal and Birka.¹¹⁹ The archaeologist Zanette Tsigaridas Glørstad points to the same arrangement on the basis of the typological similarity of ring brooches.¹²⁰ She considers the distribution to indicate that there was a power faction in eastern Norway which had strong ties to eastern Sweden in the Viking Period. She also picks out Hamar and Grue as two central zones with networks extending east, west and south. Several types of evidence thus indicate that the Solør kings had ancestors in the Uppsala dynasty, and that the region became a key centre of power at an early stage, with direct links not only to the east but also from the Viking Period onwards with the embryonic Norwegian kingdoms.

Olaf Tree-feller came to Värmland at the end of the seventh century, and his son Halfdan Whiteleg, who was brought up at the home of his uncle in Solør, was flourishing around AD 710. The reason why Värmland and Solør were subject to the same king was, according to the saga, the result of a bad year. The blame was first laid upon Olaf, and according to *Y.saga*¹²¹ he was killed as a result. This, however, disagrees with *Historia Norwegie*,¹²² where it is stated that Olaf lived peacefully and died as an old man in Sweden. Whatever, the new settlers in Värmland later understood the failed harvests not to have been Olaf's fault, but rather that it was population growth that caused shortages. For this reason, many of them moved westwards towards the Eidskog, slew King Solvi, the father of Halvfdan Gold-tooth, and Halfdan Whiteleg was taken as king. Halfdan then conquered the whole of Solør, and later, probably, Hadeland and Toten too. His brother, Ingjald Olafsson, became king in Värmland, but after his death, Halfdan annexed this kingdom as well. The extent of Halfdan's kingdom is a matter of debate, and Krag¹²³ believes from *HN* that he was the first king of Oppland, and first and foremost king of Hedmark.¹²⁴ This position was consolidated when Halfdan married Åsa, daughter of Øystein Hardråde, who ruled over Hedmark¹²⁵ and was king of Heid.¹²⁶

119 Blindheim et al. (1999) 150–151.

120 Glørstad (2010) 265–272.

121 *Y.saga*, Ch. 43.

122 *HN*: IX 32.

123 Krag (1991) 132–133; Krag (2004) 187–188.

124 *HN*: X 1.

125 *Y.saga*, Ch. 44.

126 *Af Upplendingakonungum*, in *Hauksbók*.

The saga literature does not say any more about Solør and Värmland until four generations later, when Olaf Geirstad-elf held power. Olaf, however, obtained only the lordship of Vestfold; others took power in other regions. For example, Hogni Øysteinsson was king in Hedmark and Solør. Olaf lost Värmland at the same time, because the inhabitants turned to the kings of the Swedes. According to *Y.saga*, this led to the breaking of the Yngling dynasty's power over Hedmark. The sources disagree on this, however, as, according to *HN*, Opplandene remained under the king the whole time.¹²⁷

Apart from these references, the saga says no more about Solør. Nor are the areas east of Hedemarken and Gudbrandsdal of especial significance in the saga literature. Østerdalen is mentioned in the saga of Olaf the Saint.¹²⁸ This accuses the folk of Østerdalen of being a dishonest people. They are described as being settled in small, peripheral areas along the rivers and in clearances in the forests, far from other folk. In one case of pigs and cattle having been stolen, the Østerdalers are blamed for the crime by the governor, Bjørn. The chieftain Raud from Østerdalen presented the inhabitants' case. Raud was of Swedish family and married to the sister of Ring Dagson, a minor king on Hedemarken. He and his sons were well equipped with weapons and clothing and evidently had access to wealth. The story ends with the fact that Bjørn himself was responsible for the thefts, and the people of Østerdalen come out well.

Apart from the story of the theft itself, this story provides a possible insight into circumstances in Østerdalen at the end of the Viking Period. It is stated that the settlement in the valley, along the river valley and in clearances in the forest, was sparse and scattered, and that contact with the surrounding areas was low. At the same time, though, the range of characters indicates that there was wealth, and people of high status, in Østerdalen, in addition to a network of contacts both to the east in Sweden and with the minor kings of eastern Norway. Ring Dagson was of the Fairhair dynasty and thus there was a blood-tie to Østerdalen as well. That the valley was not isolated is supported by the historian Halvdan Koth¹²⁹ who counts Raud as one of Olaf the Saint's associates.

From the archaeological evidence of ironmaking, the north-western part of Värmland is to be counted as part of the Hedmark tradition. Olaf Tree-feller has already been noted, and the area is mentioned on several occasions in *Hkr*.

127 See Krag (1991).

128 *Olav Helliges saga*, Ch. 164; see also Østmo (2000) 59–60.

129 Koth (1966) 53–54.

In many cases, the region is referred to, along with Eidskog, as a transit zone, while two stories portray the Norwegian king's interest in the region. These were when Harald Fairhair journeyed to Värmland because Erik King of the Swedes had collected taxes in the region. Harald put Erik to flight and took back the land north and west of Vänern, as well as the whole of Värmland.¹³⁰ The land west and north of Vänern is precisely those areas where the Hedmark tradition is found. In *Egilssoga* too¹³¹ there is an account of a Norwegian claim on Värmland. Here, Egil travelled around collecting taxes on behalf of Håkon the Good. This was not popular, and the king's emissaries had been assassinated twice before Egil took control by force. If one accepts that the story about Olaf Tree-feller has elements of truth, it is linked to a context which makes this connection more comprehensible. The rebellions against both Harald Fairhair and Håkon the Good show, at the same time, that Norwegian rule appears to become weaker from the tenth century. In Olaf the Saint's days it seems clear that Värmland was primarily under Swedish rule,¹³² but it is probably the southern part of Värmland that the text is really concerned with. This southern region is also mentioned later on, in the Saga of Magnus Barefoot,¹³³ where account is given of a conversation in which King Mangus and King Inge of the Swedes both claim the borderlands in Värmland. Magnus believes the boundary should follow the Göta River and Vänern to Värmland. What the situation is in the northern parts of Värmland is not discussed, and the saga literature says nothing about where the boundary between Hedmark County and northern Värmland ran.

The truth value of saga literature is a matter of debate, and much is legend and fiction. Nonetheless, there is in all probability a certain amount of reality in the accounts. Both finds and place-names support the development indicated. The literature thus tells of a petty kingdom in Solør which appears to grow from the eighth century, expanding both north- and eastwards. Värmland west of the River Klarälv was probably subject to this king at least up to the end of the Viking Period. From around the year 1000, the region fluctuated between the control of Swedish and Norwegian kings, and the land boundary must be regarded as having been fairly fluid with respect to lordship and taxation.

130 *Harald Hårfagres saga*, Ch. 14.

131 *Egilssoga*, 161–177.

132 *Olav Helliges saga*, Ch. 77.

133 *Magnus Berrfötts saga*, Ch. 12.

Other Medieval Sources

Royal Letters and the Kaupangr in Stor-Elvdal

Solør and Østerdalen are likewise only exceptionally referred to in documents from the early medieval period in Norway.¹³⁴ Of what we have, several documents are fundamental to this study. In *Diplomatarium Norvegicum*,¹³⁵ there are three letters associated with Stor-Elvdal. In a letter of 1264¹³⁶ Magnus Lawmender takes Tarald and his farm Berg in Stor-Elvdal under his protection. The farm had previously been a gift from King Håkon Håkonsson to Tarald's mother, Torunn. Two further letters from Håkon Magnusson of 1292 and 1318¹³⁷ confirm this royal guardianship. The farm must be counted as a royal farm, and the letters show that the king had interests in Koppang in the thirteenth century. The teacher Anders Fosvold¹³⁸ regards the gift as thanks for the fact that the king himself was hidden here during the Birch-legs' flight over the mountain from Lillehammer in 1204. Whether that is correct is not something I shall speculate upon, but it certainly appears highly likely that the royal farmstead has to be associated with the old trading centre and node of *Kaupangr* (see Ch. 4, Stor-Elvdal), irrespective of how it came to be. For the king, it must also have been a matter of interest to exercise control over the trading activity and the valuables that were exchanged here.

Kaupangr lay in the middle of Østerdalen, and despite what looks like a peripheral position, was centrally located in relation to likely trade routes. It was the best-known market in Østerdalen in the Middle Ages, sited approximately halfway between Nidaros and Viken. Here, the River Glomma runs from north to south, and via crossing links there was relatively easy access to neighbouring valleys both east and west. The trading sites of the inland population were also located where access was easy in winter. The archaeologist Søren M. Sindbæk¹³⁹ emphasizes the sledge as a swift means of transport, and points out that winter transport is not inferior to trade by sea in terms of the efficiency of carriage. To locate a trading site here is therefore not so strange as it might seem to start with.

Tradition relates that the market site lay alongside the River Glomma on what is referred to as 'Koppangøya'.¹⁴⁰ This was not originally an island but a

¹³⁴ See Fosvold (1936) 28.

¹³⁵ *DN*.

¹³⁶ *DN*: XI 2.

¹³⁷ *DN* XI 3 and *DN*: XI 8.

¹³⁸ Fosvold (1936) 31–38.

¹³⁹ Sindbæk (2005) 247–250.

¹⁴⁰ *Kaupangr*-island, see Fosvold (1936); Sørensen (1975); Ven (1999).

fertile river plain on which there were several farms. The area was therefore called 'Koppangsjordet'.¹⁴¹ An ancient routeway crossed Koppangsjordet. This is considered to be part of the medieval road network that is treated in Magnus Lawmender's National Law.¹⁴² The route is also part of the pilgrim way to Nidaros.¹⁴³ In the seventeenth century, this road became part of the national road network, *Kongeveiene*,¹⁴⁴ and was then greatly improved. The age of the routeway is unknown, but it has to be assumed to have been a crucial link between the north and south far back in time.

There is also reported to have been a church at Koppangsjordet, probably raised in the twelfth century.¹⁴⁵ The church is referred to as *Kaupangkirken* or *Elffueddals kirikie*, and is mentioned for the first time in the royal letter noted above of 1318.¹⁴⁶ *Elffuedal* reveals the earliest form of the name of Stor-Elvdal. The archaeologist Oluf Rygh also stated that the name of the settlement area was *Elfardalr* throughout the Middle Ages.¹⁴⁷ The church was eventually destroyed by a major flood but its site is known through archaeological investigations in 1922 and 1995.¹⁴⁸

In 1922, the parish priest, Sigurd Næs, undertook an excavation at the site where old tradition claimed the church had stood. Below the ploughsoil, Næs came across both stone foundations and graves, together with stones incised with the cross. Gerhard Fischer inspected the site and confirmed that what had been found were a medieval church and its burial ground. The church wall was built in the dry-stone technique. An excavation of 1995 also confirmed this. One of the graves was then radiocarbon-dated to AD 992–1286 (TUa-1813, 870 ± 95 BP, pine). The wide range makes interpretation difficult, but from the accounts of when the church was built, the most probable date is AD 1150–1250.

In 1925, Næs undertook an excavation of a mound 100 m long and 2 m high around 200 m from the site of the church.¹⁴⁹ He identified three foundation walls with associated laft-building. In the bottom layer several artefacts were found that are dated to the 13th and 14th centuries.¹⁵⁰ The objects included

141 Koppang-field.

142 *Landslova*, Ch. 45.

143 Berg-Hansen (1996) 5.

144 *Via Regia* or King's roads. Established in Norway from the seventeenth century.

145 Bjørnstad (1987).

146 *DN.*: XI 8.

147 See Fosvold (1936) 9; Ven (1999) 14.

148 Fischer (1922); Berg-Hansen (1996).

149 Gamle Kongeveg (1997) 35.

150 The newspaper *Østlendingen*, 3 November 1925; Sørensen (1975) 41.

knives and a spearhead.¹⁵¹ Also a metre-thick layer of cooking stones was found stretching over 50–60 m. This layer consisted of scorched stone, charcoal and bone. The layer of cooking stones was also investigated in 1995. At that time, its extent was determined to have been 100 m × 140 m.¹⁵²

The archaeological findings show that there had been large-scale activity at Koppangsjordet in the High Middle Ages. The activities had also been multifaceted. Inger Marie Berg-Hansen¹⁵³ suggests that there may have been a transit station here associated with the transport route. I am doubtful that this was the sole function, however, as the size of the layer of cooking stones represents more activity than an inn alone would have produced. Large assemblages of cooking stones are found in a range of circumstances. This type of ancient monument is most commonly found in the flat settled districts on Hedemarken and in Oppland, at farms with names of early form. In more peripheral areas such as at *Kaupangr* they are not so usual. I believe, as a result, that the presence of the cooking stones and other archaeological traces have to be associated with the old trading site, where a transit station may have been one component.

A question which follows is why a trading site was founded here. One point, of course, is the situation, with practical trading routes in all directions. The origin of the market cannot, however, be explained by a favourable position alone. Trade goods of local and regional origin must have played a leading role. In my view, it was products from the outlying land, and especially from ironmaking, which are the immediate reason why the market site was placed here. Iron was an important form of currency of exchange for other goods. Additionally, other goods from the economy of the outlying land, such as hunting products from the massive enterprise in Rendalen, were key products.¹⁵⁴ Grain output was low in Østerdalen, and the exchange of outlying land's and agrarian products lay at the heart of the trading activity. The volume of iron production and hunting mean that high-value exchanges were taking place, and since the royal authority was represented at the farm of Berg, it appears to me that the king must have stood in a central place in this network. At the royal farm of Berg, the king's associates could regulate, organize and secure much of the trade network without being directly involved in production itself. Such government could function either through the exercise of power or by controlling and taxing the trade indirectly. I regard it as likely that the king exercised

151 Gamle Kongeveg (1997) 35.

152 Berg-Hansen (1996) 10.

153 Berg-Hansen (1996) 12.

154 Bergstøl (2008) 66.

indirect rule, controlling the trade rather than production itself. From the wide geographical extent of this production, I do not regard the idea of direct control as realistic. This type of system requires considerable resources, which are not reflected in the historical sources. Direct control requires a major infrastructure. Pedersen¹⁵⁵ believes, amongst other things, that no such system was present with respect to the control of craft at the Kaupang in Skiringssal, Vestfold, but rather that the king and his allies functioned by placing orders and supplying raw materials. In the much more decentralized area in which the Hedmark tradition is found, we have to assume that control will have been harder to establish and maintain than at *Kaupangr*. It is more likely that the king made use of agreements and goods to stimulate production, and possibly also to order products for further sale in a market governed according to external demand. In the following section, I shall focus on certain sources that support precisely such a model.

The National Assembly and Law of Royal Succession of 1273

At a national assembly in Bergen in 1273, a new law of royal succession was adopted, and it was later incorporated into the national law.¹⁵⁶ During the same assembly, in ceremonious circumstances, Magnus Law-mender divided the kingdom between his sons Erik and Håkon. Erik was the first in line of succession and received the title of king, while Håkon became duke, with control over Oslo, Ryfylke, the Faroes, Shetland and Opplandene—albeit with the exception of Østerdalen, which was to remain under the king.¹⁵⁷ The reason for this almost feudal division, in the view of the historian Grethe Authen Blom, was to ensure that Håkon also had an influential place in the Norwegian kingdom. Why these eastern parts of Opplandene were not included in his share is not explained, however, ironmaking and the income it provided to the king may have been the principal reason.

The role played by Østerdalen in the civil wars is also crucial in this respect. Before the Peace and Treaty of Kvitingøy of 1208, when Opplandene was placed under the Bagler leader Phillippus Simonsson,¹⁵⁸ Hedemarken and Opplandene were governed by the Baglers for long periods. Øystein Vigrestad¹⁵⁹ points out that the Bagler leaders in Opplandene were organized in the civil war period into a local power structure based on networks. He also believes

¹⁵⁵ Pedersen (2010) 319.

¹⁵⁶ Blom (1972) 31.

¹⁵⁷ Fosvold (1936) 41–42; Blom (1972) 40.

¹⁵⁸ Blom (1972) 11.

¹⁵⁹ Vigrestad (2009) 98, 112–120.

that King Sverre had problems in establishing strong and stable power in this region. Not until after the death of Phillippus in 1217 did the king finally achieve control, and King Håkon IV Håkonsson and Earl Skule Bårdsson appointed their lieutenants over parts of Opplandene. When Skule also gained control of Viken in 1221, Blom¹⁶⁰ regards that it was he who enjoyed the royal revenues from Opplandene. Whether Østerdalen was an element in the internal conflicts and the later power struggle between Håkon IV and Skule, we do not know. Anders Fosvold¹⁶¹ was of the view that the Østerdalers were probably friendly to the king and the Birch-legs around 1200, as the latter chose this escape route from Håkon Håkonsson in 1206. Østerdalen is not referred to very much during the civil wars, but it is picked out as a transit zone for the Birch-legs, the Ribbungs and the Baglers alike.¹⁶² Apart from one slaying¹⁶³ no conflicts are recorded in the valley system. As Hveberg suggests, this may be because at this date Østerdalen lay outside the control of the Baglers, and the royal authority had lordship in the far east. The archaeological evidence supports this hypothesis. The changing profile of ironmaking reveals a clear rise in the twelfth century, something that I consider would not have happened if the area had been directly impacted by the internal conflicts of the 12th and 13th centuries. With the region enjoying stability, it was also possible for the royal authority to stimulate, maintain and increase production, especially in a period when the need for both iron and income was rising. If Østerdalen had been affected by internal conflict and continually shifting alliances, this should be visible as periods of decline in the dating evidence, either over the whole region or in more local areas. At the same time, one should expect any power struggles or battles to have been recorded in the saga literature. This implies that whoever controlled production, or rather the distribution of the product, kept hold throughout the earlier Middle Ages. For this reason, I regard it as likely that in 1273 Magnus was still concerned to hold on to his control of *Kaupangr*, Østerdalen and the important outlying resources.

Håkon VI Magnusson's Decree of 1358 Concerning Østerdalen

There are no direct sources to confirm the position of Østerdalen in the earlier Middle Ages. The nearest are the above-mentioned royal letters from *Kaupangr* in Stor-Elvdal. The role of the king in Østerdalen is, however, clearly reflected in what is perhaps the most fundamental written source from Norway dealing

160 Blom (1972) 20–21.

161 Fosvold (1936) 32.

162 *Sverres saga, Böglunga Sögur, H. Håkonssons saga.*

163 *Böglunga Sögur*, Ch. 204.

with ironmaking in the Middle Ages: Håkon VI Magnusson's Decree relating to Østerdalen of 1358.¹⁶⁴ In this, a series of privileges and decrees that relate to the business of the Østerdalers are consolidated. One of these is concerned with iron-extraction. In clause 2 of the decree it states that *They can freely take ore for jernvinna from the king's common land, according to the ancient custom of the valley*, while clause 3 follows with: *The king's officer must not hinder them in carrying their wares to Hedmark or other towns and exchanging them for what they will*. Clause 1 is also crucial as it states that *They shall not pay more tax and toll than their forefathers have done from ancient times*. The Decree for Østerdalen is not unique, as much of the text is more or less the same as earlier written decrees from the period of Håkon V's dukeship in the 1290s.¹⁶⁵ The exceptions are the lines about ironmaking and the right to free trade. The Decree was subsequently confirmed on several occasions, the last in 1548,¹⁶⁶ but ironmaking at the level of the earlier Middle Ages was never re-established.

It is clear from these lines that the king is looking back at something that had existed earlier. The historian Asgaut Steinnes believed from the vocabulary that the text is probably referring to agreements several generations earlier, because Håkon VI uses the term *foreldri*.¹⁶⁷ The right according to ancient custom thus probably refers directly to the ironmaking that ended just before the year 1300. This is also, very probably, the case with the line of text in which ancient legal conditions concerning tax and toll are highlighted. The southern part of Østerdalen, i.e. Elverum and Åmot, is described as having enjoyed special rights and tax privileges far back in time.¹⁶⁸ The northern valley system, Tynset, by contrast, had a more regular tax situation. Only two farms, Kilde and Glomstad, were taxed at the same level as the farms in Tynset, but these high rates have to be seen in light of the favourable position of the farms. The difference in the taxation rates is seen by Steinnes in connection with the fact that Østerdalen north of Åmot was subject to the Bishop of Hamar, while the parish of Tynset belonged to the Bishop of Nidaros. The secular boundaries must be supposed to have been the same, and the ecclesiastical divisions probably had roots far back in time.

Fosvold¹⁶⁹ interprets the reason for the low tax rate as being linked to the fact that the majority of the farms were in the king's possession, and that

¹⁶⁴ *Regesta Norvegica* VI:173, no. 483.

¹⁶⁵ Steinnes (1930) 85–95; Blom (1967) 235.

¹⁶⁶ Steinnes (1930) 81.

¹⁶⁷ Means forefathers; Steinnes (1930) 82.

¹⁶⁸ Steinnes (1930) 81–85; Blom (1967) 233–235.

¹⁶⁹ Fosvold (1936) 41.

the farmers were tenants from early in the Middle Ages. The historian Halvard Bjørkvik¹⁷⁰ believes, by contrast, that the farms that were under the king and the Church in the 16th and 17th centuries were of relatively recent date, and that early in the medieval period there were few farms that were royal or ecclesiastical property.¹⁷¹ The basis of Bjørkvik's view is that the farms were small and owed little land rent, and that the king appropriated a number of farms after the Black Death.

The burden of taxation must therefore be looked at in other lights. The historian Knut Dørum¹⁷² has studied the tax figures for Romerike in the thirteenth century and found that the taxes here were below half the level of tax in Viken. The reason for this, in his view, is that the royal authority at that point still had less control than in western Norway and Trøndelag, and was least secure of all in the eastern interior. In Dørum's view, this is connected to the fact that there were strong local traditions of power and rule, and that the region succeeded in resisting heavier taxation and greater control from the monarchy.

As a region, Østerdalen is less well illuminated by written sources than Romerike. As noted, the region does not appear to have played any great role in uprisings, and only in a few cases are we told that the king's opponents travelled through the region.¹⁷³ As I interpret the picture from the few available sources, the king actually did have a stronger base there than Dørum suggests for Romerike and Vigrestad¹⁷⁴ suggests for Opplandene. I consider, on the contrary, that the easternmost parts of Norway, especially Østerdalen, became subject to the king at the transition from the Viking Period to the Middle Ages. For this reason, I also believe that the tax rules cannot be related to opposition from a strong, autonomous, elite. If we bring *jernvinna* into the discussion, it appears to me that the impression is strengthened. If it were the case that regional chieftains and leaders controlled production far into the thirteenth century, this would be reflected in the written sources. The reason for this is that I regard it as certain that the royal power, after it had become firmly established around the middle of the eleventh century, would have used its power to achieve such control. Conflict and areas of conflict are duly covered in the saga literature, and the sources do not provide accounts of uprisings or opposition in this part of eastern Norway because no such resistance took place—which

170 Bjørkvik (1972) 76, 80.

171 See also Helle (1993) 158.

172 Dørum (2004) 418–422.

173 *Böglunga Sögur*, Ch. 16; *Håkon Håkonssons saga*, Ch. 79, 104 and 148.

174 Dørum (2004); Vigrestad (2009).

again implies that the royal power was firmly established and that the community maintained itself more or less stable throughout the earlier Middle Ages.

With the archaeological evidence in mind, I also find it implausible that the level of taxation had anything to do with Østerdalen being regarded as a poor and peripheral area. Quite the reverse: the exploitation of the outlying land, and especially *jernvinna*, reveal a region whose economic conditions were good. I consider therefore that the low taxation may have been a privilege that was granted the Østerdalers from far back in order to support the maintenance and increase of production. The king had a clear economic motive to encourage greater output as he gained major income through others forms of taxation, and it was particularly important for the king to exercise control over the nodes and trade network through which the iron products passed.

The Decree has been discussed in a number of studies, and there has been considerable agreement that the king was eager to re-establish an old business. The lines that are less discussed are those concerned with free trade and taxation. The historian Andreas Holmsen¹⁷⁵ regarded the privilege of free trade as remarkable, as the king at this date was going the other way, with restrictions and bans on buying and selling. The reason, in Holmsen's view, is that Østerdalen was so peripheral that the dangerous and harmful inland trade did not reach these settlements. Jon Solem, in a discussion about common property in the Middle Ages, believes that the privilege may be a result of the king formerly having restricted the old custom of taking wood and ore in the king's forests in order to introduce a royal monopoly.¹⁷⁶ He thus concludes that the farmers who benefited from this privilege regained ancient rights as part of the king's efforts to stimulate new economic life. Tveiten¹⁷⁷ reaches a rather different view, believing that the decline of *jernvinna* in Østerdalen was the result of the king interfering with the distribution, but not in production. The right to free trade was thus meant to encourage new growth as the farmers could now freely exchange their goods.

Holmsen's idea from the 1930s is not favoured nowadays. The *Kaupangr*, for instance, shows that despite the marginal position of Østerdalen, the area was certainly part of a larger and comprehensive trading network. The other interpretations are also problematic, as I am of the view that the king did not take this sort of action in order to exercise closer control over production himself. I base this upon the fact that iron extraction goes back to the Viking Period,

¹⁷⁵ Holmsen (1932 [1982]) 63.

¹⁷⁶ Solem (2003) 264–265.

¹⁷⁷ Tveiten (2010) 25.

and the development has to be viewed in this context. In the earliest centuries, it was regional chieftains or kings who were in control. The 14C dates show that production probably began in Solør and gradually expanded northwards, until Åmot and Stor-Elvdal became established around AD 975. I consider that as early as the ninth century there was an established practice whereby the occupants of Solør and later of Østerdalen adhered to a common system of production. By then, there were already rights that boosted production with economic gain as the goal. The regional chieftains, and subsequently the king, thus had an established system, which it is unlikely they would want to break up. If the king really wished to obtain an absolute monopoly over extraction or distribution it is scarcely credible that the industry should go under, rather it should have been strengthened. I am also doubtful that this was wanted, because the established practices already provided a firm economic profit. The privileges are indisputably to the advantage of the population of Østerdalen, and they provided something more by supporting iron production and a trading network with it. A royal monopoly would have removed such a custom, and restrictions on distribution would also mean higher taxes for the Østerdalers, which does not seem to have happened.

A key question in this context is how far the right to free trade was also an ancient custom, or if it was something new, to restimulate iron extraction. As the king establishes it so directly in the text, and does not refer to custom here, it is likely that this privilege came as an addition to the others. Blom¹⁷⁸ emphasizes, like Holmsen, that such a privilege is quite inconsistent with the economic principles of this era, when central authorities were assuming a steadily firmer grip through the High Middle Ages. The control of trade was not the least in importance, and may have been especially important in the light of the establishment of the Hanseatic League.¹⁷⁹ Privileges of this type must therefore have had very clear reasons. I suspect that the king's agenda in this case was to grant a new benefit to the Østerdalers in order to refound an ancient, valuable, economic activity, even though the authorities would, as a result, have to expect somewhat lower income from this segment of the distribution chain. I shall continue this discussion further below, but it is important before that to place the iron bloomery activity within the system that was probably reigning in this region at the peak of production, the institution of common land and property.

178 Blom (1967) 235.

179 E.g. Helle (1993) 173–175, 254–255 and 268–269.

Commonalities in the Middle Ages

It is not known whether Østerdalen was part of the territory of any of the provincial laws. Sigurðsson¹⁸⁰ draws the boundary of the Eidsiva *thing* along the line of the old shires of Hedmark and Østerdalen. Claus Krag¹⁸¹ has placed all of Opplandene, including Østerdalen, under the same juridical assembly. Despite this, I assume that the outlying land of Østerdalen was also subject to the laws of common land from an early date. The Decree shows that was certainly the case by 1358, and its retrospective character implies that the practice ran several generations back in time. The laws of commonality are written into the provincial laws, especially the Gulathing and Frostathing codes, and later into the National Law. The history of common land as an institution is obscure, but the legal texts came into being in the 12th and 13th centuries¹⁸² and the practice must predate that. It was general practice of common property that the outlying land, meaning the areas beyond the farm and its own land, could be used by anyone, apart from in those areas where the king is sovereign.¹⁸³ Solem¹⁸⁴ identifies three important principles in legislation. The first is that the common land should be of ancient origin, which means that all common land is to be preserved as it is. The second is the rules for clearance, where it is the king who can give permission for clearance in the common lands, and then owns the farm. The third is linked to various clauses that relate to rights of use.¹⁸⁵ It is unnecessary to go into the background to and development of common lands, but rather to emphasize that their preservation was a high priority for local powers, while the king would want to encourage new clearance in order to expand his land and increase his income from taxation.¹⁸⁶

Tveiten has studied the institution of common property in relation to medieval iron extraction. He believes that *jernvinna* was included in the rules, but was so under the heading of 'outlying smithies'. Smithies, as Tveiten emphasizes, are largely identified close to or at the farms, and the word may therefore possibly allude to the old concept of *rauðasmiðja*, which was a medieval term for iron production.¹⁸⁷ Fundamental to the laws are the right of claim. This means that if someone puts a building up in the outlying land they have a

180 Sigurðsson (1999) 77.

181 Krag (2000) 94.

182 Solem (2003) 244.

183 Øye (2005) 10.

184 Solem (2003) 245.

185 See Tveiten (2010) 244.

186 Solem (2003).

187 Tveiten (2010) 245.

claim on the area as long as the building is in use, while at the same time there is a time-limit to how long the claim can be kept if the building goes out of use.¹⁸⁸ As Tveiten interprets this as including ironmaking sites too, I consider that the practice of raising buildings, i.e. bloomery sheds, may have been an attempt to mark a claim to an area. He particularly focuses on Valdres and Gausdal, as the charcoal pits of this tradition are also included within the ironmaking sites (=JKS), a feature which he thinks strengthens the marking of a claim.¹⁸⁹ A problem with this view, however, is that *jernvinna* in Gausdal was organized in such a way that people stayed at the same bloomery site only for one to three years.¹⁹⁰ This is indicated both by the number of charcoal pits and by the size of the slag heaps. Narmo assumes that the quantity of carbonized timber in one charcoal pit corresponds to one year's output, and as the slag heaps are relatively small, it is scarcely credible that there was any need to mark a claim in the way that Tveiten proposes. What Tveiten is certainly right about, though, is his conclusion concerning claims in the Hedmark tradition. The archaeological evidence shows there to have been no bloomery sheds. In his view, this may be evidence of less conflict, and suggests that claims were made in different ways. In fact, the ruins of huts to live in have been identified at a series of bloomery sites in Gråfjell. Since the level of production was much greater in Gråfjell, the sites remained in use over a considerably longer period than in Gausdal. In this light, these buildings could also serve to mark a claim—but I do not believe that was so. I refer to Tveiten's ideas because it is specifically the lack of conflict that is key.

The Decree says that everyone can freely extract ore according to the customs that have reigned in the valley. The letter does not, however, say anything about how this custom was expressed in practice. Investigations of *jernvinna* in Norway show that the organization relating to extraction of ore varied. The bloomery sites themselves are often placed close by the source of ore, and this created a monopoly on that source. The picture is different in the Gråfjell area, as the ore sources often lie far from the production sites and many producers must have used the same source of ore. This form of organization, however, probably developed over time. In Solør, where the earliest sites of this tradition are found, there was also ironmaking at the ore source. Gradually, as the activity spread out and grew in intensity in the late Viking Period, a consistently operated system under which the good resources of ore were common property developed. The fact that the king emphasized free access to bog ore can

188 See Solem (2003) 256.

189 Tveiten (2010) 253–254.

190 Larsen (1991); Narmo (1996a).

be seen in this light: he exercises governance to ensure that no individuals can monopolize particular sources of ore.

This regional bloomery ironmaking was firmly grounded in the society of Østerdalen, and archaeological excavations have not yet found traces of contemporary ironmaking with its roots in different traditions. The system was constructed so that rights and duties were interconnected, without the business appearing to have been particularly contentious. It was this custom that the Decree in all probability looks back to. Although the forests at this date were subject to the conditions of common land, the system was not interfered with because there already existed established guidelines and practices which all agents, i.e. the smelters, the farmers, the chiefs and the king, benefited from. As long as the practice was preserved more or less unchanged, it was unnecessary, as was proposed above, to make any changes. It thus seems probable that the king did not deliberately intrude and make changes which could damage a well-established system. The additional privilege that came with the Decree can be seen in the same light, in my view, as it is quite clearly economically directed. Although it diverges from the steadily more strongly controlled trade policies, it is possible to identify why the king took this step just at this date. In Chapter 8, I shall return to this discussion, there focusing on the economic circumstances of the Hedmark tradition. Before that, however, it is necessary to gain an insight into how the historical sources relate to the extent and boundaries of the Hedmark tradition.

Boundary Zones and Affiliation in the Iron Age and Middle Ages
Värmland and Hedmark are referred to as a single region in the Icelandic sources. A kingdom is described here, lying between the two great rivers, Glomma and Klarälv/Göta älv,¹⁹¹ and the kingdom, which was called Alvheim, stretched as far north as the source of the rivers.¹⁹² The region is also referred to as To-flodslandet¹⁹³ or Olaf Tree-feller's kingdom, and despite the fact that the sources are dubious, several scholars believe that such a kingdom or chieftaincy may have been a reality.¹⁹⁴ In the literature, Alvheim is considered to lie between the River Glomma and the Göta älv, corresponding to Bohuslän and Østfold up to Sarpsborg and Fredrikstad.¹⁹⁵ Whether the northern part of Värmland and Solør/Østerdalen on the other side of the national border were part of Alvheim

191 *Søgubrot*.

192 Flateyjarbók, see Edberg (1980) 115.

193 The land of two rivers.

194 Edberg (1980) 115; Hansson (1990) 59.

195 Bugge (1910) 55.

is not recorded, apart from what appears in *Flateyjarbók*, but the fact that the River Klarälv is referred to as Österälven¹⁹⁶ in the Middle Ages is regarded as a clue, as the Glomma was regarded as the Vestre Storelven.¹⁹⁷ The name Elverum, in the variant forms *Elfr*¹⁹⁸ or *Alfarimr*,¹⁹⁹ is also used as evidence that the kingdom extended at least this far north. It is probably more accurate to link this with the proper name of the Glomma, which was called *Elfr* north of Elverum. The historians Gustav Storm, Steinnes and Krag²⁰⁰ also therefore consider that Alvheim was not a territorial kingdom but rather a royal estate. Steinnes was also of the view that the name could equally well derive from a royal name Alv, as from the word for 'elf', and that this legendary kingdom had never existed in reality. However, even though Alvheim has no connection with the northern part of Värmland and Solør/Østerdalen, the descriptions of a possible unified region between the Rivers Glomma and Klarälv/Trysil are significant. The author Rolf Edberg²⁰¹ regards this as natural, as lakes and river courses provided natural boundaries and were important factors in the original dividing up of Scandinavia. H. Amundsen is of a similar view. The national boundary as it exists nowadays should consequently be described as topographically unnatural. The landscape that it cuts through is a homogeneous and bounded environment with continuous forests and large lakes.²⁰² Several scholars also view the region as a common cultural zone from its ancient monuments and finds, from the Stone Age right up to historical times.²⁰³ The present-day boundaries only became a reality in the Middle Ages.

That a region which ran across the national boundaries was once a reality is corroborated by the saga literature, where Olaf Tree-feller cleared the land along the river that runs into Vänern and created his kingdom in these forests. Adam of Bremen²⁰⁴ also reports that the Värmlanders dwell between Norway and Sweden. He is here probably referring to the group of people who lived in these forest zones and, as late as early in the Scandinavian Middle Ages, were fully integrated neither to the east nor the west. It is also important to point out that the boundary as it appears to have been constructed in the 11th and 12th centuries did not necessarily constitute a dividing line for the people

196 The eastern river.

197 The western great river; Edberg (1974) 9, (1980) 115.

198 E.g. Bugge (1973) 7.

199 Torgals (1937) 128.

200 Storm (1877) 482; Steinnes (1950) 368; Krag (1991) 229–232.

201 Edberg (1980) 115.

202 Edberg (1974) 10–11.

203 Olsson (1974) 17; Svensson (1998); Holm (1999); Myrdal-Runebjer (1999).

204 Adam of Bremen (1075 [1993]) 205.

in the area itself.²⁰⁵ Rather than the border being seen as a break point for natural contact, the dividing line was initially unproblematic because the local populations' alignments and networks were governed by natural conditions, customs and traditions. A loose network of contacts of this kind does, however, appeared to disappear in the course of the Middle Ages as the new national kingdoms displayed greater interests and needs to control the area, and from the middle of the twelfth century at least, the population of Värmland had become subject to the rule of Sweden.

The first record of a fixed boundary between Norway and Sweden is from 1030 in the Västgöta-law. This, however, concerns only the southern end of the border,²⁰⁶ and Värmland-Hedmark County is not referred to. The first record of a boundary line between Värmland and Hedmark appears between 1260 and 1283.²⁰⁷ Six men from either territory met to review the border, and they fixed 17 boundary points.²⁰⁸ A problem is that the text is somewhat incomplete when this part of the border is discussed. Werlauf²⁰⁹ thus concluded that the boundary between Värmland and Hedmark was further east than it is now. North of Värmland, he moves the border all the way to Karlstad, and he believed that the north-western quarter of Värmland was subject to Norway at the end of the thirteenth century. The historian Erich Christian Werlauf used the politician and historian Jacob All's translation and interpretation of *Hkr*²¹⁰ as his point of reference. Both the historians P.A. Munch and Erik Noreen²¹¹ criticized this interpretation as legendary, and believed that the border appeared for the most part to have been more or less like the present one. Noreen also took the view that the majority of the boundary-markers mentioned in 1273 were located in places largely agreeing with the modern national border. The greatest shift in the boundary line lies between Trysil and Värmland, and it is clear that the Swedish and Norwegian kings were in dispute over where the line should be.²¹² Further north, the border diverges from the modern line, naturally enough as Idre and Särna were Norwegian territory in the Middle Ages.²¹³ The historian

205 Östberg (1974) 52–53.

206 Hansson (1990) 59.

207 Reproduced in Werlauf (1845); see also Munch (1846); Noreen (1919); Holm (2003).

208 Holm (2003) 195–196.

209 Werlauf (1845) 155.

210 From 1838.

211 Munch (1846) 158–161; Noreen (1919) 134–135.

212 Noreen (1919) 134–135; Torgals (1937) 127–135; Friberg and Friberg (1987) 182; Hansson (1990); 64.

213 Friberg and Friberg (1987).

Olof Holm,²¹⁴ who has studied the border north of the study area, supports the view of a border whose ancestry goes back to the Middle Ages, but with the understanding that, despite its determination in the thirteenth century, the border was primarily an oral entity, and thus was asserted by way of traditions, and that it was the local population who kept it firm and stable.

From this, the conclusion can be drawn that before the eleventh century there was no clearly defined border between Solør/Østerdalen and Värmland. As the sagas recount, ever since the eighth century the area had been characterized by conflicts of interest between east and west, and the forest zones had repeatedly changed hands. From the eleventh century onwards, Värmland probably became a more secure part of the Swedish kingdom, at least in theory. How this expressed itself in practice is unclear, however. From the archaeological evidence, it would appear as if the population that made its living in these forests in the western part of Värmland, even in the early part of the Middle Ages, may have been operating in a grey area where traditions and networks of contacts were just as important as any superordinate political affiliation. Throughout the Middle Ages, however, this north-western part of Värmland became subject to firmer and more direct control from the Swedish king.

The Local Administration

In the Middle Ages, Solør and Østerdalen belonged to separate administrative districts. Solør was part of Hedmark, while Østerdalen was a district on its own.²¹⁵ There is very little information about Østerdalen, but the region was divided into two *sysler*,²¹⁶ and the best defined boundary emerges from a study of the diocesan administrative areas, with Østerdalen north of Hanestad belonging to Nidaros and the area to the south to Hamar.²¹⁷ This boundary is thought to be earlier, and to be based upon ancient folkland and territories.²¹⁸ The division of Østerdalen into two *sysler* is also clearly reflected by differences in the tax rates.²¹⁹ The southern part of Østerdalen is referred to as Åmot, and the *syssele* of Åmot extended south to Elverum and Hamar. To the east, Åmot extended to the national boundary, and in the west it ran along the modern county boundary with Oppland.

²¹⁴ Holm (2003) 149.

²¹⁵ Helle (1993) 208; Krag (2000) 187.

²¹⁶ Shires.

²¹⁷ Andresen (2003) 97–98.

²¹⁸ Helle (1993) 208.

²¹⁹ Steinnes (1930) 84.

Hedmark was also divided in two, with Solør as the eastern portion. This bordered on Åmot in the north and extended from the east side of Mjøsa to the national border. To the south, Hedmark bordered on Hadeland and Romerike. There is much to suggest, however, that Solør formerly had close contacts to the north, and also to the east. There are, for instance, close ties in naming traditions²²⁰ and in types of ancient monument.²²¹ In later tax lists, Solør and Østerdalen are also closely linked together.²²² Additionally, the saga literature distinguishes between Solør and Hedmark in the pre-Conversion age. In contrast to Åmot, which kept its ancient borders, Solør was made subject to a new administrative area, probably in the second half of the twelfth century when the region was plagued by civil strife, and the office of *systemann*²²³ was created.²²⁴

The local administration also took different forms.²²⁵ While *herreder* and *fjordunger*²²⁶ with moot sites were established in Hedmark and Solør, it does not appear that any such system was created in Østerdalen. It is likely, then, that the local administration comprised earlier subdivisions following traditions that were never put down in writing.

There is thus a clear divergency in the development of these two areas in the Middle Ages. Solør appears clearly to have been straightforwardly integrated into social development from the twelfth century onwards. Østerdalen, however, was more marginal, and the sources imply that the valley was not directly brought in in the same way. In the twelfth century, Solør was also made subject to the Eidsiva *thing*, while the situation in Østerdalen is unclear. Nonetheless, the office of *systemann* functioned here too, and in this way the king exercised control, even if less directly. By the end of the thirteenth century, in any event, Østerdalen had become an integrated part of the royal realm. In a decree of Magnus Håkonsson from 1273,²²⁷ the sheriff of Østerdalen is given the duty of turning out with five fully equipped men in cases of disturbance. Hedmark meanwhile, along with Hadeland, had to turn out 22 men.

220 Bugge (1973).

221 Holm (1998); Svensson (1998).

222 Bjørkvik (1972).

223 A sort of governor.

224 Krag (2000) 123.

225 Indrebø (1935).

226 Equivalent to 'hundreds' and 'quarter-hundreds'.

227 *Regesta Norvegica*, RN 11, 106.

Concluding Remarks

The peripheral role of Østerdalen has recurrently been noted as a reason why the king did not see this part of the country as of economic importance. The sources show that, in the earlier Middle Ages at least, Østerdalen did not adhere to the same administrative development as elsewhere in eastern Norway. One view is that the old popular administration, probably with long-established chieftains as the executive power, provided the framework of the local form of governance during this period too. Subsequently, this existing system was developed further with local governors, or stewards, and later sheriffs entering into the effective power structure.

The royal farm of Berg at Koppang also shows that the king was present with direct control over *Kaupangr* at least by the thirteenth century. Before this, however, probably in association with the colonization of the Viking Period and the growth of *jernvinna*, a system was established in which major or minor chieftains controlled trade and exchange at *Kaupangr*. At the same time, the trading site of Hamar was founded, where it is to be assumed that Åker played a key role in exercising control.

It is not agreed when the king achieved lordship over Solør and Østerdalen. The most common view is that of the local historian Hveberg.²²⁸ He believes that Solør was first subjected to the crown under Olaf the Saint in 1015, and that the district became Christian in 1021. He bases this upon the fact that Olaf moved the old *thing* site of Oppland to Eidsvoll, amongst other things. Several scholars point out, however, that Opplandene, with which Østerdalen is partly integrated and partly excluded,²²⁹ enjoyed a relatively free position, with several minor kings up to the 1060s, when Harald Hardråde finally forced the region into the Norwegian kingdom through harrying and destruction.²³⁰ The fact that Harald had coins struck in Hamar around AD 1060 is also a clear sign that the area was then subject to the king. However, the sagas also tell of the interests of several of the Viking Period kings in this region and their network of contacts here. The archaeologists Helge Braathen and Skre²³¹ have argued that the equestrian graves in Romerike show that there were royal military and administrative centres here in the Viking Period. Dørum disagrees, and argues rather that there is no good evidence for seeing Opplandene as subject to the monarchy in the Viking Period. He regards the equestrian graves instead as

²²⁸ Hveberg (1972) 19–20.

²²⁹ See Dørum (2004) 11–12.

²³⁰ E.g. Andersen (1977) 153; Moseng et al. (1999) 79; Krag (2000) 74–75; Dørum (2004) 36–43, 48–50, 423–425.

²³¹ Braathen (1989); Skre (1998).

traces of men who served a regional chieftain, but considers that the minor kings of Opplandene could nevertheless have submitted themselves to Harald Finehair and his successors.²³² Glørstad²³³ agrees in part with Skre and Braathen. She emphasizes that the location of the equestrian graves in relation to the Huseby farms makes it difficult to interpret them in a local political context alone. She considers, however, unlike Skre and Braathen, that the graves are not necessarily to be seen as features of royal administrative centres of the Viking Period; rather that they represent the formalized, personal allegiance and dependency that she believes are expressed by the ring brooches and the cape. She concludes, like Dørum, that Harald did not conquer the interior of eastern Norway, but that he gained political allies and supporters early on, and that they had seats at Hamar and Grue.

The picture which has emerged agrees nicely with the development described in this chapter. In the eighth century at the latest, chieftainships were established in Solør and Värmland, with networks of contacts to the south and east. The network must be considered to have been based upon alliances, with the exchange of goods as a central factor. But since already by the early eighth century, bloomery ironmaking with the production of a surplus had been established, I believe that trade with the aim of making a profit rapidly became crucial for the chieftainship. Towards the end of the Iron Age, the region gradually became more subject to the national kingdom at the same time as it expanded to the north. I also think that from the middle of the eleventh century, the king had established control over the whole of Østerdalen and thus also achieved indirect control over ironmaking. With more formal business, linked to a number of trading sites, and a general increase in population, came also a gradually higher level of extraction, an activity from which all the operatives in the chain of production appear to have benefited materially.

²³² Dørum (2004) 26–30, 42.

²³³ Glørstad (2010) 271.

Tales of the Iron Bloomery

The Hedmark tradition has now been set in a broad context. In the following chapter, the results will be discussed comparatively, in order to consider the society that was involved in more detail from spatial and chronological perspectives, and to discuss what this region may have looked like as an economic entity in the late Viking Period and Middle Ages.

The discussion will focus closely on the principal questions, which in Chapter 1 were posed as:

- Technological and organizational features revealed by the investigations in the Gråfjell area
- *Jernvinna* in Hedmark as a distinct technological tradition
- The organization of the iron bloomery and the exploitation of resources
- The dating of the ironmaking
- Production as part of an economic system
- A controlled and governed activity

The Technological Concept and Coordinated Activity

How the Hedmark tradition can be understood as an economic and political system was discussed at the end of Chapter 3. I put forward the hypothesis that bloomery ironmaking was founded upon and determined by a strictly applied concept which compelled the agents to cooperate. The basis for these conclusions has three layered components:

- The technology, i.e. the actual process of ironmaking
- The organization of the bloomery sites
- The organization of the activity in the landscape and the use of resources.

Jernvinna in the Gråfjell area appears to have been homogeneous, with consistency in both technology and organization. This is made evident by a comparison of technological and organizational details, both at the bloomery sites and in charcoal-making. All of the sites examined are based upon a specific model. The variable that the evidence reveals is size. Variation does not diminish the uniformity of the technology, but rather sheds light on geological

and topographical factors, or on varying needs. After a review and comparison of all the key components of the production sites, I concluded that the activity was based upon a fixed model. Irrespective of size, all of the sites are organized according to a *basic model*, from which a predominant style of organization identified as the *standard model* was developed. Irrespective of topographical circumstances, production adhered to this pattern of organization.

In contrast to Narmo's conclusions from Rødsmoen, where inconsistencies in the evidence were interpreted as reflecting different ideas and traditions, such as opposed to domestic production against production for exchange, I believe that the bloomery ironmaking quite clearly displays a uniformity that has to be regarded as a monolithic tradition at both the technological and organization levels. This view is reinforced when landscape and the use of resources are considered too. The bloomery sites were placed at certain intervals in the landscape, and the charcoal pits are clearly linked as they surround the sites like swarms. The basis for location was therefore that the workers at the individual sites had a right to use the wood in the vicinity, which in turn implies that the production sites were not randomly placed but rather followed a specific system. The roasting sites, however, are distributed differently. Only at a few of the production sites are there bogs rich in ore, and in some cases, the closest source is situated several kilometres from the bloomery site. Roasting was almost entirely carried out immediately adjacent to the sources of ore. This means that even though the agents had effective right of use of a given area around the ironmaking site, the ore sources were common. This implies that no one could impose a claim on the rich sources, e.g. by placing the bloomery sites right beside the bogs. According to ancient principles of commonality, there was a custom for making a claim over an area, for instance by raising a standing building. For the individual ironmakers, such a practice would clearly have been preferable, but as it does not appear, I believe that there must have been regional rules and practices which gave everyone the same right to the bog ore, irrespective of where the iron was extracted. If the activity had been more individually governed, I would expect, by contrast, that claims and rights to resources would have been expressed by placing the bloomery sites right alongside the ore bogs. Yet another aspect that supports this perception is that the timber resources around the rich ore bogs were reserved entirely for the roasting process, as demonstrated by the almost complete absence of charcoal pits from these areas.

From these facts I postulate that *jernvinna* in the Gråfjell area was based upon a strict, uniform, technological tradition: a tradition which, as well as being based upon a common concept, was also an activity in which cooperation was practically obligatory.

Methods in the Borderland

Regions and Patterns of Use

The homogeneous bloomery ironmaking that has been found in Gråfjell is clearly different from other known production centres in its technology, organization and use of resources. As I have already noted in the review of furnace types and the organization of tapping technology in Norway (see Ch. 2), a general feature of medieval iron extraction is the great similarity in the technology of furnace construction and process. It is primarily a greater or lesser variation in organization which produces local and regional differences. Slag tapping furnaces which have been discovered by excavation in all regions are shaft furnaces with external insulation formed of sand, stone slabs and, on occasion, wooden cases. The same type of furnace is also predominant in Sweden, east of my study area. Thus to the east, north and west there existed other traditions, with sharp contrasts to the Hedmark tradition.

With respect to organization too, the differences between Hedmark and the rest of southern Norway are great. As noted in Chapter 2, south-eastern Norway is divided into several regions on the basis of patterns of use. As well as the Hedmark tradition, there is the Møsvatn tradition, the JKS tradition, and possibly a fourth tradition in the area between those two.¹ This division has been based upon variables in the archaeological evidence, not only in patterns of use but also in bloomery sites, and variations in charcoal-burning expressed in the form and the organization of the charcoal pits in the surrounding landscape. The Møsvatn tradition includes the Møsvatn area, but it probably extends southwards to Hovden in Bykle. The JKS tradition is defined by the research in Dokkfloy, but is distributed between Hallingdalen and Gudbrandsdalen.

An important contribution to the regional debate has been Tveiten's doctoral thesis² which deals with *jernvinna* in Langfjella. He has examined two areas in particular, Sudndalslia in Hallingdalen and Lillefjell in upper Valdres and has found clear differences between these areas. The sites that he has excavated and examined in Valdres show clear similarities to the JKS tradition, although the early dated sites also present parallels with Møsvatn. Tveiten points out, however, that there was a development, from charcoal pits being found in the area around the bloomery sites to their being integrated into the site: in other words, to having the organization of the JKS type.

The research in Sudndalen and Hallingdalen produces a different picture. Here, Tveiten finds two patterns of use, one represented by sites with furnace

¹ Narmo (2000).

² Tveiten (2012).

sheds and charcoal pits placed in the surrounding landscape—with similarities with both the JKS and Møsvatn traditions—and the other with furnaces and slag heaps associated with a single slag heap, known as *charcoal pit sites*. He considers the latter a specific, eponymous type for Hallingdalen, while the former is part of a larger area of tradition that includes Telemark and Aust-Agder too. He also considers that sites with a bloomery shed are larger than the charcoal pit sites, and that they may therefore represent a larger-scale and more specialized enterprise. The reason why there are two patterns of use or traditions, and overlapping technological solutions, lies, in his view, in the fact that regionalization is a process that varies in time and space rather than deriving from ready-made, unvarying entities. Consequently, he also defined a fourth area of tradition, Hallingdalen, from its peculiar charcoal pit sites.

The studies of Tveiten and Narmo show that there are manifest differences in patterns of use, but that variations occur within the regions in question as well. I have already pointed out that there are also clear similarities between the regions (Tab. 8.1) and that the method and organization are probably rooted in the same Late Iron Age technological development—a point I shall return to (see Ch. 8, The Hedmark tradition in time and space). A weakness in the regional debate is that little attention has been paid to chronological development. In fact, through a chronological study, it is possible to see how the regions have developed from what I regard as a common starting point to more differentiated and ultimately specialized traditions. As appears in Figure 8.1, development is relatively uniform, apart from in Hedmark. Tapping technology was introduced in the thirteenth century and production was then undertaken at open bloomery sites. Furnace sheds were first introduced at Lillefjell in the tenth century. In the course of the eleventh century, production in furnace sheds became the norm for the whole area. In the same period, as Tveiten points out, there was also a development that saw the charcoal pits become a more integral part of the site structure. The exception is the Møsvatn tradition, where the charcoal pits continue largely to be located in the landscape around the sites.

Through a chronological study, therefore, I conclude that in the Viking Period and Middle Ages, up to around AD 1200, one cannot speak of clearly different regional practices of *jernvinna* in this area. The exception is the charcoal pit sites that appear in Hallingdalen from around AD 1050. It is only well into the twelfth century, and particularly in the 13th, that one can find clear signs of divergent development. This is primarily indicated by the charcoal pits being pulled in and integrated into the site structure in Valdres and Gausdal. From AD 1250, the development culminates in a production-line style of organization, christened the Dokkfloy type, being established in Dokkfloy along with

TABLE 8.1 *Technological and organizational differences between the traditions of south-east Norway and the Hedmark tradition in the Viking Period and Middle Ages, after Rundberget (2011) 195.*

Technological and organizational differences			
Component	Element	South-Norwegian tradition	Hedmark tradition
<i>Furnaces</i>	<i>Superstructure</i>	Circular/oval shafts of clay insulated by stones/slabs.	Circular shaft, no insulation.
<i>Furnaces</i>	<i>Substructure</i>	No pit, sometimes a shallow depression in the surface.	A pit below the shaft, wall constructed by stones and a barrel shaped wooden wall on the inside.
<i>Furnaces</i>	<i>Support</i>	Thick walled shaft supported by the slabs or a wall bank.	Free standing shaft, no support.
<i>Furnaces</i>	<i>Slag tapping</i>	In small descending channels in ground level.	Ascended 20–30 cm from the ground or in pits right outside the shaft.
<i>Furnaces</i>	<i>Slag terminology</i>	Draining slag.	Tapping slag.
<i>Charcoal pits</i>	<i>Shape</i>	Commonly circular, square occurs.	Only square, mostly quadratic, rectangular occurs.
<i>Charcoal pits</i>	<i>Size</i>	Often small and shallow, larger pits are not unusual.	Mostly larger pits, more or less a fixed shape both in area and in depth.
<i>Charcoal pits</i>	<i>Number</i>	Rarely more than 3–4 on each site.	2-> 30 pits connected to each production site.

TABLE 8.1 *Technological and organizational differences between the traditions (cont.)*

Technological and organizational differences			
Component	Element	South-Norwegian tradition	Hedmark tradition
<i>Charcoal pits</i>	<i>Organization</i>	Next to the production site, often three in a row.	As dots around the production site, distance up to 500 m.
<i>Bloomery sites</i>	<i>Scale</i>	Often a small production, 2–5 tons of slag.	small, < 1, to large, > 60 tons of slag.
<i>Bloomery sites</i>	<i>Organization</i>	Often in small houses, one or two furnaces at the same time. Ore stored under the roof, charcoal stored in the pits.	No traces after houses, often two furnaces which shared stores of ore and charcoal in between. One slag heap to one furnace.
<i>Bloomery sites</i>	<i>Occupation</i>	Often double-roomed buildings one part for production and one for housing.	Small dwelling building next to the production sites.

Gausdal and possibly Øyer too.³ With the exception of Hedmark, with its particular, established organization with its roots back in the eighth century, there are no places where one can point to such a defined and fixed practice as that which is seen in Dokkfløy in this relatively short period of 50–100 years.

Narmo⁴ connects the development of the Dokkfløy type with a shift from a self-sufficient economy to a more complex craft economy. He believes the cause to lie in the establishment of kingdoms and, subsequently, the power of the Church. These institutions did not exercise their influence directly, but a predictable and more stable mercantile network was established through the political system. This development took place particularly in the period of AD 1250–1350, when the Dokkfløy type appeared and the highest surplus

³ Larsen (2009) 128.

⁴ Narmo (2003b).

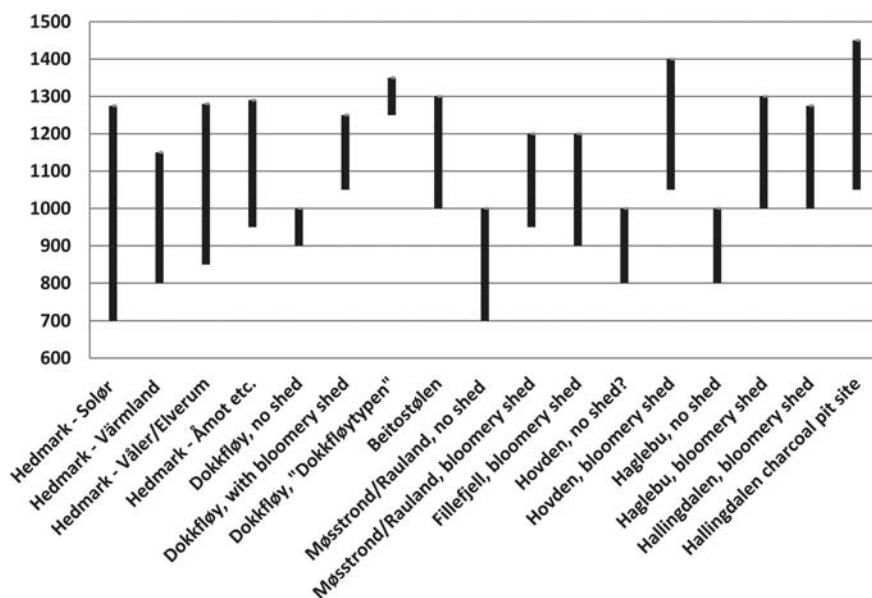


FIGURE 8.1 *The chronological development of ironmaking regions in South-East Norway in the Viking Period and the Middle Ages*

production was seen. It was probably the episcopal estate strategy in Gausdal and South Gudbrandsdalen that was the basis for this, as the greatest estates created by the bishop were precisely the great cereal farms of South Gudbrandsdalen, in Gausdal in particular. The rent from these farms was huge quantities of grain. Narmo believes that this grain was mostly marketed locally, and it was not necessarily grain or agricultural produce that was transported out of Gausdal; rather iron of equivalent value: iron bought in a cheap market for sale in a market where the price was higher. In the forges of the Bishop of Hamar, the value of the iron was increased further and it was transformed into tools and weapons. The development of the Dokkfloy type thus reflects the same indirect control that the royal authority had probably practised in Hedmark somewhat earlier.

The Land of Difference

The Hedmark tradition contrasts with everywhere else in southern Norway, where there was a tradition of ironmaking with the same apparent origins (see Tab. 8.1). These dissimilarities are situated at various levels, and they are sufficiently great that the basis of the tradition has to be interpreted in the light of separate development. There is, at the same time, a general homogeneity in

the evidence from the excavations and surveys carried out in southern Hedmark, where no particular borders between different traditions developed. I believe therefore that the thesis of a uniform activity, called the Hedmark tradition, applies to the whole of the study area. From this starting point, I was able to proceed from the conclusions referred to above, relating to technology and organization, and so to use the extent of the Hedmark tradition to define the boundaries of this regional tradition.

In Chapter 4, I concluded that the Hedmark tradition covered a territory which included the southern and eastern part of Hedmark (Fig. 4.15). The basis for the location of the boundaries has not been explained, however. The boundary line varies in nature. To the east and west it is clearly determined by the watercourses of the River Glomma and the River Trysil/Klarälvs. There are no equivalent physical boundaries to the north and south, where forest zones spread out in both directions. Here, something other than purely physical factors must have determined the extent of the tradition. I have already shown that Østerdalen was divided into two administrative districts or *sysler*. The border between them ran past Atneoset, running north-east to Hanestad and further eastwards into Rendalen. South of the border lay Åmot *syssele* and to the north that of Tynset. These lines are considered to have been rooted in earlier systems than the kingdom's and the Church's administrative boundaries which were defined in the Middle Ages. The northernmost recorded sites in Rendalen have a striking location in this light, as the distribution corresponds closely with how far north Åmot *syssele* extended in the thirteenth century.⁵ To the south, the tradition comes to a stop approximately at the national border, defined by the site Martens excavated at Skotterud. South of Eidskog, in Arvika, Sweden, as of yet not one single site of the Hedmark type has been identified, and the closest charcoal pit has been recorded more than 20 km from the border. The date at which the modern boundary between Hedmark and Värmland was established was discussed in Chapter 7, The written sources. The sources indicate that the borderlands between Eidskog and Arvika were apparently defined much earlier than those further north, probably before the year 1000. The northern boundary between Värmland and Hedmark (Kongsvinger-Våler), however, was more fluid in character in the earlier medieval period. Not until around AD 1150 are there relatively secure sources showing that the border zones had been placed directly under the control of the Swedish Crown.

Thus, both the northern and the southern borders were defined by pre-existing dividing lines. Explaining the eastern and western boundaries, meanwhile, is more problematic. The clear fact is, nonetheless, that the ironmaking

5 E.g. Helle (1993) 208; Moseng et al. (1999) 193.

can be shown to extend between the two great watercourses. There is one exception, and that is the production found in the forest zones that extend west of the River Glomma towards the settled districts of Mjøsa. This westerly extension is best explained by the strong position this area offered the chieftain or king and its proximity to the trading site of Hamar. That does not, however, explain why other areas west of the River Glomma, except the three sites in Imsdalen, Stor-Elvdal, were not incorporated. The same phenomenon recurs in the void landscape east of the Trysil River and Klarälv in Värmland. East of the Klarälv, apart from the site at Västra Tandö in Lima, not one certain site of the Hedmark tradition has been recorded. This underlines the point that the river is to be seen as the border mark rather than the national boundary, at least in the earliest period, and I shall return to this point in due course.

What these boundaries running from north to south imply is as yet an unanswered question. There are few sources that shed light on the situation. There are, however, several explanatory models. If it was the case that the *jernvinna* was so resource-intensive that the forests were more or less denuded for the best production, the boundary can be seen as a link in a social structure that preserved the woodlands east and west of the rivers for different uses. There was demand for good timber both for building and for other enterprises. There was, for instance, massive consumption of timber in connection with transhumance and dairying. In more recent times, this is particularly shown by the production of brown cheese. The exploitation of the woodlands in this period has been studied in Grimsdalen, amongst other places.⁶ Each shieling was granted a certain amount of woodland for fencing material, sawing and building. Large amounts were also granted for winter shielings and cheesemaking. The problem was two-fold. The assaults on the woodlands were large-scale, while pasturing simultaneously prevented regrowth. The situation in Grimsdalen is not unique, and large areas of woodland are essential for both transhumance and ordinary farming. This is, of course, not a directly applicable comparison, as we have little knowledge of the total need for timber in early times in a farming community. However, there will also have been some level of pressure in the Middle Ages, as the regulations concerning common land indirectly show. The organized exploitation of woodland resources may thus have been a feature of areas such as Østerdalen, where ironmaking was the principal consumer.

Information about the earliest stage of shieling farming in Østerdalen is relatively sparse, although documentary sources show that this activity in Åmot can definitely be traced to the Middle Ages, and probably somewhat earlier.⁷

6 Risbøl et al. (2011) 33 with refs.

7 Amundsen (2007) 141.

Evidence of pasturing has also been identified back to the Early Iron Age. The study of shielings at Stavlia, for instance, reveals a period of use at the transition from the Viking Period to the Middle Ages.

In earlier modern times, transhumance was extensive in the higher valley systems. Fully 96% of the farms in Mid-Østerdalen had a shieling in 1723,⁸ and I would assume that transhumance was also widespread in the Middle Ages. In the Gråfjell area, there are several shieling sites with dating evidence that reveals activity in the Late Iron Age and throughout the Middle Ages, although their use appears to become more intensive from the fifteenth century onwards⁹— a feature that is believed to be repeated in several parts of Østerdalen.¹⁰ This is quite remarkable, as the valley was by all accounts severely affected by the depredations of the Black Death.¹¹ Holm is of the view that the increasing amount of pasturing in the outlying land of the late Middle Ages reflects a new economic situation, when those who had survived in the community had to compensate for the collapse of *jernvinna* and the opportunity it provided to obtain grain through exchange.¹² This again is no startling idea: a new economic approach was essential, and pasture in ready-cleared ironmaking land was quite practical. However, the question remains as to whether or not that is correct. Holm is rather uncritical of the relevant 14C dates, and she uses the earliest parts of the date ranges without comment even though the activity could equally well be of the seventeenth century. All the same, there are several earlier signs of activity at the shielings in the Gråfjell area, and I consider it likely that the shieling sites with 14C dates from the Late Middle Ages also have earlier phases that have not been revealed. The dated features are predominantly buildings and fireplaces. The early 14C dates at Rødsetra and Melgårdsetra, by contrast, are from other contexts, which could not easily be found in small-scale test pits and trial trenches.

Although it cannot be verified from the evidence available, I believe it to be overwhelmingly probable, if not necessary, that several of the shieling sites in the Gråfjell area were in use before the Late Middle Ages, and not necessarily simply as shielings. This view is based upon the fact that I see the known settlement as being too sparse to have been able to sustain the ironmaking. It is to be stressed here that production was similarly high south and east of the Gråfjell

8 Sanderød (1996) 69–71.

9 Holm (2003); Amundsen (2007) 139, with ref.; Stene (2014).

10 Holm (1999); Risbøl (2008) 285.

11 E.g. Sørensen (1981); Sørensen (1999).

12 Holm (2003) 85.

area, and that the known farming population of Åmot altogether cannot have been large enough to have supported the ironmaking.

There are some sources which in my view may support the idea of a forest farm population of this kind. The saga literature presents such a form of settlement in the story of Raud from Østerdalen, and because it is mentioned as a type, I regard this form of settlement as having been widespread. The archaeological evidence likewise points to settlement of this kind. On Rødsetervolla, there have been many shielings of historical times which were linked to the Rød farms, in addition to the fact that the farm Rød Mellem was moved there in 1882.¹³ Excavations of the old shieling sites have shown that there had been activity here as far back as the eighth century. After a period of abandonment following about the year 1000, new clearance for cultivation, haymaking and pasturing was introduced in the thirteenth century, and permanent farming settlement was in place from early in the fourteenth century.¹⁴ No buildings from the thirteenth century have been identified, and this may be linked to the use of the land. There may have been some form of labile exploitation of the wider outlying land and settlement could have been less permanent. The fact that large areas around the shieling sites dated to the Middle Ages do not provide any signs of iron extraction, except for one site at the shieling itself, may be evidence of such a practice. As noted, that is the picture at Rødsetra. One small bloomery site and four charcoal pits were recorded below the shieling site (Jfp.16, see Ch. 3). Otherwise, the landscape is characterized by the complete absence of activity associated with ironmaking. This type of landscape continues eastwards all the way to Vestre Æra (see Fig. 3.4). In a topographical view, there is no apparent reason why bloomery ironmaking should not have been undertaken here. However, the presence of the shieling and farming activity may have been the reason. A comparable absence of intensive iron extraction appears at the shielings of Kjølsetra, Knubblia and Deset Østseter. At the first of these, no nearby ironmaking has been identified, but at both Knubblia and Deset Østseter *one* single small bloomery site has been found, which I assume must be linked to settlement activity. Even though it is based upon a barely representative number of sites, the pattern is that the areas around shieling zones with possible periods of use back to the Viking Period and Middle Ages were not used for bloomery ironmaking on any large scale. Whether or not this element was a decisive factor in where different activities were carried out has to be a topic for future research. However, if the hypothesis is regarded as credible, the phenomenon stands out as yet another aspect of the clear and

13 Risbøl et al. (2001) 72–73.

14 Amundsen (2007) 233.

systematic organization of the resources and landscape in the Gråfjell area. If so, it can also explain the delimitation of iron extraction and organization within the landscape in other parts of the region too.

A similar picture has been proposed by Holm¹⁵ in Grundsetmarka, north of Elverum. Here too, two phases of use with an intervening period of abandonment in the Viking Period and earlier Middle Ages have been identified. The bulk of the activity here is also in the Late Middle Ages, but there are indications of cultivation in the earlier Middle Ages as well. Bloomery sites and charcoal pits have been recorded in the area, and it can be considered likely that the economic activity in Grundsetmarka and at Rødseter were of the same character: a forest farm settlement with extensive agriculture and pasturing combined with intensive bloomery ironmaking.

Another possible and likely explanation of the river boundaries may be that customs, traditions and beliefs have from an early date been associated with the area of distribution of the ironmaking, or that the rivers were also genuine regional boundaries. From her studies of the processes of change from the Early Neolithic to the Pre-Roman Iron Age between Mjøsa and Femunden, Amundsen¹⁶ has concluded that the Trysil River was a boundary line as early as the Late Stone Age and Bronze Age. East of the river a culture based on hunting dominated, with its core area in Engerdal. The areas west of the river, by contrast, are dominated by artefacts that can be linked to the early farming cultures of Hedemarken. Early written sources refer to a kingdom which lay between the two rivers (Ch. 7, The written sources) and Olaf Tree-feller is reported as having cleared land in Värmland, west of the River Klarälv. The truth value of the historical accounts is uncertain, but Amundsen's work, amongst that of others, may indeed indicate that there were extant physical boundaries from an early date, and that these were maintained when more extensive colonization got under way in the Late Iron Age.

Physical boundaries have already been noted, elements that have always been crucial for people and communities, without needing purely practical explanations. Physical boundary lines against the unknown may not least have been crucial for the first immigrants who settled in the valley. Such boundaries may be defined by contact with the already established hunting population, and through challenges posed by new topographical and climatic circumstances. Strömberg¹⁷ has studied how a new population with bloomery ironmaking as one of its core occupations cleared land and settled in Halland and

15 Holm (2004) 112–118.

16 Amundsen (2011) 285.

17 Strömberg (2008) 77.

Skåne. The colonization proceeded, in Strömberg's view, through old barriers being breached while new boundaries were formed. The borders are not static but are based upon mental perceptions.¹⁸ They are created in a cultural context on the basis of a specific historical situation, and create identity through creating distance from others. In this context, the historical situation was the bloomery ironmaking itself. Strömberg believes on this basis that the breaching of old barriers against the unsettled, the building up of knowledge of the landscape, resources and ironmaking practice, are crystallizations of a local process of identity creation. A similar development may lie at the root of the Hedmark tradition, the definition of boundaries being constructed through a process whose goal was to establish a shared space based upon identity and connectivity.

The Development of Settlement in the Study Area

If such a view is to be a sound hypothesis, the development of settlement in the study area has to conform to the boundaries defined. As shown in Chapter 7, Settlement and its development, large parts of Østerdalen stand out because of their late colonization. The exception is Øvre Rendalen, where there are definite signs of settlement in the Early Iron Age. The finds imply that the settlement had come from Sweden or Trøndelag. The area lies immediately to the north of the northernmost known site of the Hedmark type. The absence of bloomery sites and the probable migration routes leads me to consider that this area was not the origin of the tradition, and I shall not include this community in the following discussion.

There was also a wide Early Iron Age settlement in Hedemarken within the study area, but apart from these two regions there are only a few signs of farming settlement in Østerdalen before the seventh century. What implies some form of activity in the period are bloomery sites of the Østland type that have been recorded in Åmot and Stor-Elvdal. Bergstøl interpreted these as sites operated by groups from Hedemarken. I am doubtful about this. It is unlikely that the iron smelters travelled far north into Åmot in order to make iron when the resources required were available practically on their doorsteps, and when there are many signs of Early Iron Age ironmaking in areas closer to settled districts in Hedemarken and in Elverum. On the other hand, I do not believe either that it was the groups already present who adopted *jernvinna*, as A.B. Johansen suggests. It is therefore most logical to propose that it was a small group, closely linked to the cultures further south, who were acting in

18 See Mogren (2008) 190.

the forests even before AD 600. Other forms of evidence that support this are signs of pasturing and cultivation, together with cooking pits.

Settlement that can be associated with an agricultural society is, all the same, extremely sparse in the Early Iron Age. Nonetheless, the archaeological finds, and the farm-names, show that both in the settled districts of Solør and in the south of Østerdalen, a group based on farming had settled, possibly from the end of the sixth century, but certainly from the seventh century onwards. The settlement was founded first in Solør and spread northwards. At the same time, people may certainly have come from the already settled rural districts of Hedemarken. There is little in the evidence to identify an area of origin. In Våler, there are clear parallels in names with settlement in southern Solør and Värmland. The southernmost areas of Solør, meanwhile, are linked with Romerike, in this case again through farm-names. No similar features have been noted in Østerdalen, but an expansion from the south and east is most plausible, not only from the evidence, but also in view of the fact that the Iron Age population of Rendalen did not expand to the south.

Both the archaeological and the historical sources also reveal that Solør, especially Grue and Hof, stood out as a strong polity from an early date. Major farms were established here, and there is a relatively rich collection of finds compared with the areas further north. The written sources speak of Olaf Treefeller establishing contact with the king of Solør in the seventh century. It is claimed that Solør had been cleared three generations before this meeting, which chronologically agrees nicely with the archaeological evidence. What really happened, and what is just legend, we can hardly tell, but from the consistency of the evidence I believe that the reports may be based in fact. As I understand it, Solør became a powerful chieftainship in the seventh and eighth centuries, and subsequently began to expand into the more or less unsettled north. From the Viking Period, we have clear evidence of greater colonization of the north, and it was particularly the districts around Elverum that were at the heart of this. But the northward migration continued, albeit rather later, as it is in the ninth and tenth centuries that settlement really seems to start to develop in the Rena area, a growth that continued throughout the Viking Period and on into the thirteenth century.

Attempts have been made to explain the background to the development of settlement in Østerdalen on various occasions. Traditionally, the farming settlement of Østerdalen was thought to have been based in a self-sufficient farming community. The foundation stone of this is A.W. Brøgger's hypothesis¹⁹ of an armed, battle-hardened, band of farmers of the sixth century having

19 Brøgger (1942).

sought out good agricultural land and pushed out an extant hunting culture. To begin with, immigration was small-scale, and not until the ninth and tenth centuries did greater colonization take place. Brøgger bases his conclusions on the burial evidence, and his view has formed the basis of later understanding of the area. Other groups of sources have not received any great attention, and the picture is thus rather unsophisticated, especially in a landscape where agrarian farming has been less significant than in the rich agricultural districts. It is only down in the rather narrow river valleys that there was space for substantial agriculture. The forest and its resources dominate, and it is self-evident that these resources were decisive for the very existence of the community.

The Example of Åmot

Since the 1990s, the picture has also gradually changed as a result of the major surveys of the outlying land. The enormous amount of evidence that we have from the outlying land clearly reveals the importance of the resources of this zone in every period. In particular, it is the archaeological surveys and excavations in Åmot that have produced new information about the development of settlement and the context of the outlying land.

The results from Rødsmoen plainly undermine Brøgger's thesis. The evidence here has been interpreted in terms of two different cultural groups functioning from the early Merovingian Period onwards.²⁰ One of them was a farming population which was directly linked to the farmsteads. The best revealed is the farm of Nes, situated within the confluence of the River Glomma and the River Rena.²¹ The farm Nes does not exist with this name today, but the farm called Kilde which now stands here probably split off from it.²² The earliest 14C dates are from the second half of the sixth century, but there are several 14C dates from the Merovingian Period which indicate that the farm had been founded. Agriculture following the pattern typical of eastern Norway in the Iron Age was practised. The farm lay in a central position in relation to communication routes. In the nineteenth century, there were several barrows at Nes²³ and a number of finds of the Viking Period have been made.²⁴ Part of the farm cemetery was excavated in the course of the Rødsmo Project. Foundation trenches and settlement traces of the Merovingian Period and Viking Period were identified. From its position and the associated burial ground, Nes

20 Bergstøl (1997) 83.

21 *Åmot* or *Åmotet* means river-meeting.

22 Narmo (2000) 115–119.

23 Nicolaysen (1862–66) 59.

24 Berg-Hansen (2007).

is viewed as a leading farm or chieftain's seat, but not an ordinary farm of the usual type. There are no definite signs of other farms with an equally long period of use, but finds and burial forms, position and place-names, indicate that some farms had been cleared in the Merovingian Period,²⁵ and that a small but permanent settlement had been established here in the Viking Period.

A second group that was operative in the area, according to Bergstøl and Narmo,²⁶ is represented by hunting sites, hunting-zone graves and field terraces. The hunting pits have 14C dates that may go back to the Bronze Age, and they went out of use at the transition between the Early and Late Iron Age, at the same time as the settlement at Nes was established. Bergstøl considers that the reason why hunting came to an end was that this group gradually came to regard this area as less attractive for seasonal occupation and so moved to other marginal zones.

A somewhat different model constructed by Narmo²⁷ is that there was no such antagonistic encounter. He rather believes that in the Late Iron Age two groups with different economic strategies were functioning. In this period, the agricultural settlement used only a little of the territories of the hunters, as is reflected in the scarcity of signs of an agrarian culture in the forest areas. Evidence of pasturing and settlement has been discovered at the shieling of Stavlia, but, that apart, only two small bloomery sites have been found which testify to exploitation of the outlying land. The reason why the hunting sites came to be disused is not, in Narmo's view, to be explained by the hunters abandoning the area. He rather treats hunting as an aspect of goods production rooted in a gift-exchange system ruled by chieftains in the Early Iron Age. The demise of hunting is then an expression of the socio-economic crisis that manifests itself towards the end of the Early Iron Age.²⁸

The harmonious situation suggested, however, came to an end at the close of the Viking Period, with the introduction of an economic system under which the traditional hunting and fishing areas were taken over by intensive bloomery ironmaking. In Narmo's model, the group of hunters was still not driven out; rather they adopted agriculture in their own style. Narmo bases this conclusion on the fact that he found a range of ideologies connected with ironmaking, and he believes this phenomenon must be the product of a heterogeneous community in which the earlier hunting culture had also been incorporated.

²⁵ Sørensen (1979) 83; Narmo (2000) 114.

²⁶ Bergstøl (1997) 86–92; Narmo (2000).

²⁷ Narmo (1997) 184–186.

²⁸ Narmo (2000) 81.

The Gråfjell area differs from Rødsmoen in that the hunting sites came into use after AD 600 and continued to be used until the sixteenth century, albeit with a break during the centuries when *jernvinna* was at its peak. Hunting was relatively rare in the Iron Age, and most intensive from the fifteenth century into the seventeenth.²⁹ A minor hunting system in Skrubbaldalen is the only one with ¹⁴C dates that match those of *jernvinna*. This, however, is located outside the area of intensive extraction, and the explanation can be found precisely in the organization of the use of the landscape.

We cannot tell from the chronology and evidence we have whether or not it was the same group of people who were hunting in Rødsmoen up to the end of the Early Iron Age, and in the Gråfjell area from the seventh century. Hunting overlaps chronologically with the earliest signs of activity at Rødsetra, which go back to AD 700. The evidence for pasturing and cereal cultivation shows that a settlement had been founded that early. The settlement at Rødsetra from the fourteenth and fifteenth centuries is believed to represent a year-round settlement with clear contacts to the agrarian settlement.³⁰ Stene³¹ believes that hunting was an integral part of the economy in the Middle Ages, and she postulates a combined economy involving agriculture and the outlying land in this late phase. How things looked in the Late Iron Age is less certain. The basic evidence may imply that the earliest phase of hunting could also have been connected to the settlement at Rødsetra, and that there was no hunting population functioning here as there was at Rødsmoen.

Alongside Rødsetra is the bloomery site Jfp.16, in use in the period c. AD 1175–1250. The earliest signs of activity at the shieling site are, as noted, from the eighth century. There are also several signs of pasturing back in the Viking Period. There is, however, no evidence of buildings earlier than the fourteenth century, with Tuft II dated earliest, at AD 1305. A sample of charcoal from beneath the lines of sill stones has been dated to AD 1000–1025. This ¹⁴C date is understood to reflect the clearance before the building was raised. It is logical, from the context, to link the settlement at Rødsetra with ironmaking. Another point is that this ironmaking site is not within the main area of iron extraction—which I consider a clear sign of a relationship between it and the farm of Rødseter.

Similar correspondences occur at other shieling sites in the area. Deset Østseter comprises Melgårdsetra and Søgårdsvollen. In the case of both shieling sites there is a single ironmaking site within the bounds of the modern

29 Stene (2014).

30 Amundsen (2007).

31 Stene (2014).

farm. At Melgårdsetra, we also have ^{14}C dates that match the iron production. Two ^{14}C dates from Tuft I are contemporary with the ironmaking at Jfp.7. Slag was found within this building ruin. No other traces of activity around the shieling contemporary with Tuft I have been found and the bloomery site must therefore be linked directly with this settlement.

The bloomery site at Knubblia is also to be seen in this way (Fig. 3.4). Neither the shieling site nor the bloomery site have been dated, but it would be extraordinary for there to be a minor ironmaking site here if there was no connection between them. The association with shielings or farms is, as shown in Stor-Elvdal (Ch. 4.2.2), also a common phenomenon of the Early Iron Age in eastern Norway.

The clear connection between the bloomery sites and the shielings implies that the iron smelters came from the farming community. A point in support of this is the bone found at the bloomery sites. With the exception of one fragment of red fox bone and one of beaver, the assemblages consist of domesticates, with pig, sheep/goat and cattle all represented. If a semi-assimilated hunting culture had played a role in *jernvinna* as Narmo proposes,³² one would expect a greater representation of wild animals in the diet. Since this is not the case, I conclude that the earlier culture that was operative in these forest areas did not participate directly in the work of iron extraction. *Jernvinna*, both the minor Early Iron Age production and the large-scale effort of the end of the Late Iron Age and Middle Ages is therefore, in my view, a feature of a settlement that became established at the moment when this activity got under way. This conclusion is based upon the finds and monuments from Åmot and Grundset in Elverum, and I regard it as credible for other parts of the study area too.

The Hedmark Tradition in Time and Space

I have already mapped out the chronological horizons of *jernvinna*, starting locally in the Gråfjell area. The principal objective there was to consider when the individual bloomery sites had been in use, and from that to observe how production varied through time. For the 28 bloomeries with more than three radiocarbon dates, I used the Bayesian approach to model the most probable period of use. This led to the conclusion that production started around AD 875 and that the activity was more or less abandoned around AD 1275–1290. Only one site has a possible period of use post-1300. Output in the first century

³² Narmo (2000) 189.

of production was relatively low and the activity grew in the twelfth century. The peak of production appears to have been in the period c. AD 1150–1250 and then the intensity of work declined rapidly (see Fig. 6.4).

Using this as a starting point, the Gråfjell area was compared with other parts of the study area. The region was divided into 6 areas and the 14C dates from each area were compared. The result showed internal variance in the commencement and cessation of the activity. It is manifest that production started first in Solør. *Jernvinna* then expanded northwards and over the course of 200–250 years spread out to its maximum extent. Production continued in most places until the late thirteenth century, except in Värmland where it was given up as early as c. AD 1150.

When compared with the development of settlement, there is a strikingly good correspondence between the different sources. Apart from the earliest, meagre settlement that appeared all over Østerdalen in the Early Iron Age, it was in the seventh century that clearance really gathered pace in Solør. In the ninth and tenth centuries, there was major colonization around Elverum, and towards the end of the Viking Period and in the Middle Ages, clearance was at its peak north of Elverum. On the basis of this agreement, I see a close connection between settlement and *jernvinna*. I also believe that it is logical to suppose that the great colonization was the result of a desire and the need to produce iron in this thinly populated region. This means that I do not regard the new clearance as being primarily the result of a need for new farmland. Large parts of this region, as noted, have marginal agricultural land, and the new settlers would have needed to obtain grain from other rich agrarian districts.

A model that I think may be credible, though, is that in Solør and Värmland in the seventh and eighth centuries a powerful chieftainship based economically on both agriculture and the outlying resources had emerged. Concurrently, local bloomery ironmaking was introduced on the basis of ideas from outside and/or innovation as well (see below). In economic terms, it was essential to take control of areas with rich outlying resources. The large forest areas in the north were very sparsely populated, and an expansion to the north would appear to have been logical in this economic light.

How the technology was developed in practice is hard to say. I have already proposed as a hypothesis that the smelting furnace of the Hedmark tradition is a *hybrid* of various traditions.³³ On the basis of a number of archaeological excavations of very recent years, I have formed the view that new traditions developed along with the tapping technology, specifically with clear tendencies towards hybridization. It has previously been claimed that there was a break

33 Rundberget (2012).

in production between phase I and phase II: in other words, iron production ceased completely for a period of 100–200 years.³⁴ More recent research,³⁵ however, has produced ¹⁴C dates which clearly point to continuous production throughout the Iron Age, albeit with a marked decline in seventh to ninth centuries. It is precisely in this period that the archaeological evidence provides traces of furnace types that appear to be hybrids. Amongst these I have drawn attention to the flag lined furnaces already mentioned. More recent excavations demonstrate that this type of furnace is a small slag pit shaft furnace which, however, developed over time into a slag tapping shaft furnace: i.e. a hybrid of two technologies. These furnaces are mostly dated to the seventh and eighth centuries and may be a technological form that is left over from the slag pit technology. Although the tapping technology was introduced, with a limited level of output, along with bellows and the use of charcoal, in this period a small, flag-lined pit was still constructed below the clay shaft. This feature quickly disappeared, however, and in most ironmaking regions of Norway the thin-walled shaft furnace with external reinforcement became the sole type. The disappearance of the pit is directly linked to the provision of furnaces with an external insulating frame, in my view, so that the need for insulation below disappeared. Tveiten³⁶ came to a similar view in his thesis and he believes that the change proceeded primarily in the higher land around Langfjella. The flag lined furnace that was excavated at Lisætra in Øyer does not fit this view, however, and I consider it likely that these new ideas were more widespread.

In Hedmark County, the evidence points to a different course of development. In the Roman Iron Age, the method of ironmaking was the same as elsewhere in eastern Norway, with production in the so-called Østland furnace. From the sixth and seventh centuries, a new type appears. At Rødsmoen, shaft furnaces with slag pits have been excavated, albeit of smaller size than the Østland type.³⁷ Contemporary with the slag pit furnace at Rødsmoen was smelting in a tapping furnace in the Gråfjell area (Jfp.18). This furnace does not yet have any known counterparts in the archaeological evidence. It had no proper pit, but the base slags had impressions of wood, which imply that there was a hollow below the furnace shaft. The tapping slag also proves to have been tapped from a height of c. 15 cm. The hollow below the furnace was probably very shallow, or a natural dip in the ground was used. Large quantities of shaft material show that this was a shaft furnace. No form of external insulation was

34 Narmo (1996a); Espelund (2005).

35 E.g. Larsen (2004); Larsen and Rundberget (2009).

36 Tveiten (2012) 254–255.

37 Narmo (1997).

identified, such as a different fill, stones, slabs or the like, and the furnace was, in my judgement, a free-standing slag tapping furnace with a shallow hollow that was probably primarily intended to isolate the structure.

The furnaces from the end of the Viking Period and the Middle Ages all have isolation pits underneath, and I consider it possible that this feature was developed through hybridization, when the furnace technologies overlapped in the seventh century. In the case of both types of furnaces, reduction took place in a free-standing furnace shaft of a similar size. The details that most clearly indicate such a development are the size of the furnaces and the preservation of a pit beneath with obvious shared aspects. The furnaces were stone-lined in both periods, and the lining in the pits of the Hedmark tradition may be a continuation of the wooden grate that was characteristic of the Early Iron Age. My view, then, is that through the testing and exchange of ideas, a technological innovation emerged: a smelting furnace with the potential for large-scale and long-term production without unnecessary interruptions. This is the factor which constitutes the important difference from other contemporary smelting furnaces in Norway. Because it was possible to keep production going, efficiency and output improved, and this meant greater economic profit.

Where and how this development first appeared, the available evidence does not really show us. There are some indications, though. In the eighth century, the tapping technology was brought into use in Solør. The organization of the sites and the form of the slag heaps show clear similarities with the Hedmark tradition. At the same time, though, the sites are located on sloping ground, a feature that connects with Early Iron Age ironmaking but is untypical of medieval *jernvinna*. The intermixture of a typical Early Iron Age positioning and technology, and organization which belongs to later phases, leads me to view these sites as a prototype of the Hedmark tradition. An unknown factor, meanwhile, is the form and method of use of the furnaces, as no sites of this type have had a modern excavation. Falck-Muus investigated a slab-lined pit, which he interpreted as a pit furnace, at Tyskeberget in Åsnes, not very different from the sites I have interpreted as an early phase of the Hedmark tradition. Falck-Muus's excavations are not easy to interpret, but his pit furnace theory is unfounded in the light of modern knowledge. One possibility is that he had excavated an isolation pit like those investigated in Gråfjell. But as he has recorded stone slabs, the structure may have been somewhat different, possibly based in an earlier slag pit tradition. Typical tapping slag, the form of the slag heap, and the position of the furnace in relation to the heap, clearly demonstrate a connection with the Hedmark tradition. However, the fact that the site had only one slag heap (see Fig. 3.2) indicates that it may be early. The somewhat different description of the structure of the pit may

therefore be because the site is several centuries earlier than the furnaces in the Gråfjell area.

This may be where the key to how this furnace type emerged lies, and an excavation would probably have been able to produce some answers to these questions. The prototype of the seventh century has not been found outside Solør, and, considering the evidence as a whole, it is natural to believe that it was in this area that we encounter the developmental step from the simple and unsystematic to the strictly defined tradition that appears at the latest in the tenth century, and where the smelting furnace as we know it around the turn of the millennium can effectively be considered the signature piece for the massive business that was practised in the three centuries that followed.

This conclusion is based upon several hypotheses rather than on definite archaeological remains, and that is a critical matter. If it is sustainable, it does, however, agree well with the history of the development of settlement and the chronological dimension of *jernvinna* of the Hedmark tradition. But the hypothesis also presupposes that there was a settlement concerned with iron production which preceded the Hedmark tradition, as I have also already argued. This is documented through the Østland type in the Roman Iron Age and at Rødsmoen at the transition to the Late Iron Age. The reason why this type is not more commonly found is probably due to production having been very limited, so that the production sites are practically invisible.

Approximately contemporary with, and in the same area of influence as, the newly established chieftainship of Solør, a new form of iron bloomery technology appears that swiftly turned into a central economic element of the regional chieftaincy. In the following centuries, both settlement and iron extraction expanded northwards to the extremely resource-rich forest areas in southern Østerdalen (Fig. 8.2). However, since I believe that from the very start this production was subject to distributional control, it is likely that the chieftain, and later the king, also encouraged groups of people to clear land and adopt ironmaking in these new and alien territories. Nothing suggests that this was done through force or the use of unfree labour, but rather it was achieved through the use of economic advantages, benefits that are recorded in written sources several centuries later, when the Crown had taken over control of the enterprise.

Nevertheless, *jernvinna* was probably not the sole factor behind this colonization. The need for other outlying land resources and a steadily growing population in eastern Norway were also factors that led to expansion. That the colonization is explained by a need for new agricultural land, however, is something that I am rather doubtful about. This sort of conclusion is typical of historical scholarship, as agriculture is regarded as more or less

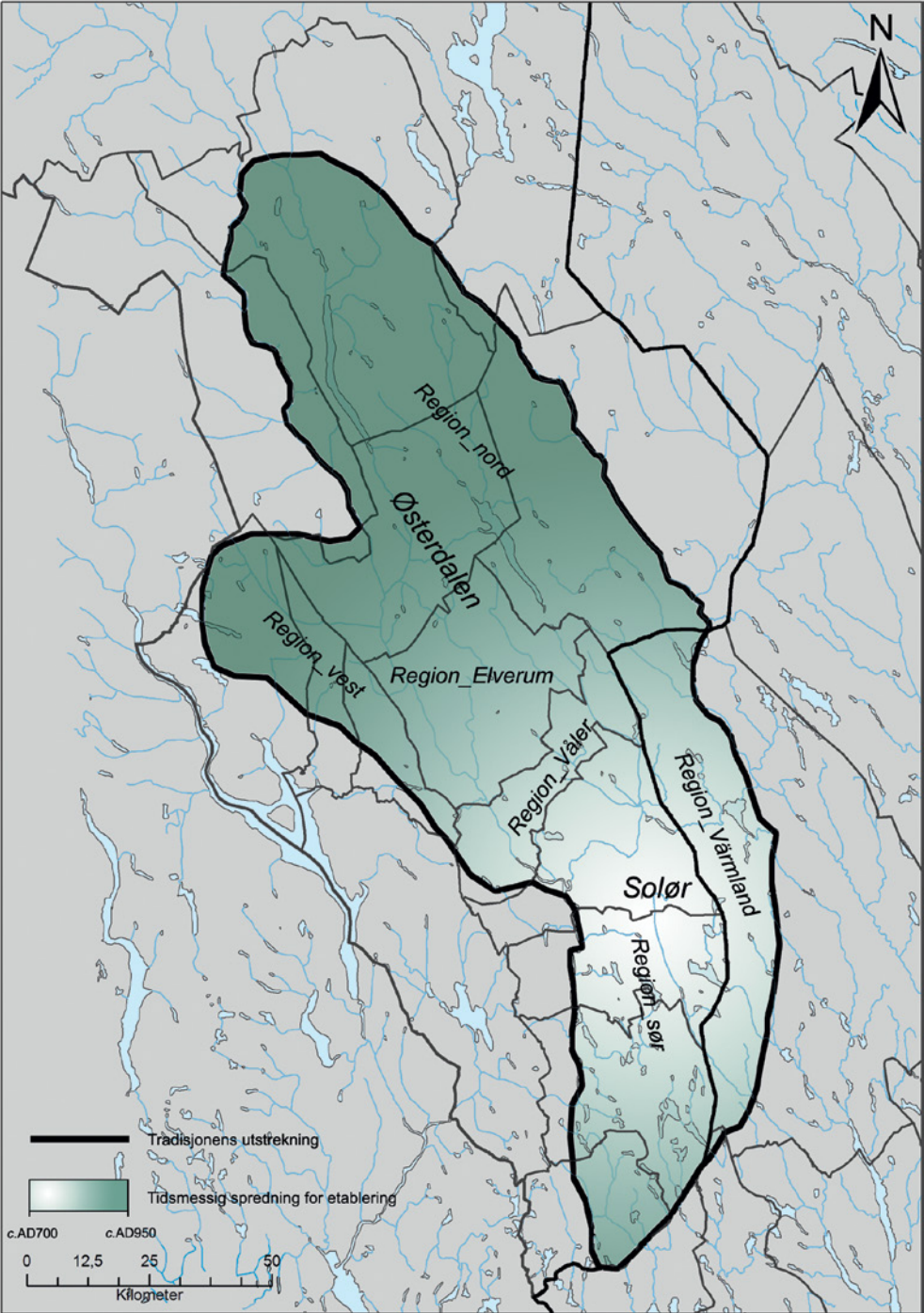


FIGURE 8.2 *Chronological range of the start of the Hedmark tradition*
MAP: B. RUNDBERGET, MCH.

solely determinative of the development of the kingdom after the Viking Period. Such views, however, are not only characteristic of Norway: the emergence and development of societies with large-scale metal production is preferentially explained in terms of surplus production in agrarian economies.³⁸ In Norway, this is largely derived from the established hypotheses involving self-sufficient farming societies as an economic model, where taxes and tithes from farming provided the economic bedrock of the Crown and the Church. Unfortunately, little if any attention is paid to the archaeological data concerning the outlying land. It is not least my own discoveries which show that different economic systems must have reigned, even in the High Middle Ages. By this, I do not mean that agriculture played no part; it is simply unlikely, rather, that it was a central element. The development was governed by several factors, as Krag³⁹ also indicates in his history of Norway. He particularly emphasizes trade and craft as crucial for chieftains' and royal power in the Viking Period, and picks out iron as an especially important commodity. High medieval trade is not going to be discussed of itself, but as I understand Krag, trade was no less important after the end of the Viking Period, even though more importance is attached in his study to agriculture in the following Middle Ages.

The development of the Hedmark tradition, as I have described it, from a small economic yield to a fully developed economic system on a large scale and with a high economic yield, does bring out further elements that have not been discussed yet. One is how and at what level possible political control may have been exercised. Another element is how the work itself was carried out and in what way it was part of the economic system. That point will be discussed first, and after that, I shall try to place the bloomery ironmaking within a wider context related to political control and its economic role.

Specialized Work

In a discussion of *jernvinna* as part of an economic system, a crucial question is how the work was carried out in terms of specialization. In Norwegian research on *jernvinna*, several studies incorporating such a perspective have been produced⁴⁰ (see also Ch. 1, *Jernvinna* as an industry?). The anthropologist Cathy L. Costin is of the view that the degree of specialization has to be related to variation in the participation of individuals and groups in the economic

38 Golden (2010) 186–190, with refs.

39 Krag (2000) 31–34.

40 E.g. Bloch-Nakkerud (1987); Martens (1988); Narmo (1996a); Bårdseng (1998).

activity, as well as to the relationship between producers and consumers.⁴¹ The basis for specialization to exist at all within a society, she argues, has to be that individual agents choose to produce a surplus and trade rather than to produce for their own essential needs. This, however, requires that an economic system which allows one to undertake this type of enterprise already exists.⁴²

In order to define how a craft is specialized, according to Costin, one must first create criteria that distinguish specialized craft or production from domestic activity. She points to four parameters which cumulatively describe the degree of specialization of an activity:⁴³

- *Context*: the degree of influence of the elite on production. In this regard, the agents may be anything from totally independent to utterly subject to authority
- *Concentration*: whether production is focused or dispersed. This includes the number of production sites within a given territory
- *Extent*: the quantity of production from small-scale domestic use to factory or quasi-industrial output
- *Intensity*: whether the production is undertaken by part- or full-time specialists. A highly specialized business does not have to be the agents' only activity: it may involve both full-time and part-time specialists at different levels.

From these parameters, Costin has outlined 8 levels of specialization, which range over a spectrum from autonomous agents producing for the household through groups or workshops who produce for regional demand to highly specialized craftsmen who work full-time for an elite or the authorities.

Also central to Costin's model is how the craft is organized. This covers who is responsible for production, who governs production, and how it is distributed. The producers may be independent individuals or groups of farmers, individuals or groups who undertake the work part-time in place of paying tax, or paid/supported individuals or groups of full-time workers who work according to the requirements of an elite or a governing institution. The latter group can be associated for the most part with industrial work, and is not a type which was widely found in the Middle Ages.

Costin's variables are useful in defining the degree of specialization in *jernvinna*. The Evenstad tradition, for instance, could be measured as having a low

41 Costin (1991) 3–4.

42 Golden (2010) 98.

43 Costin (1991) 8.

degree of specialization, while the ironworks that were founded from the end of the sixteenth century have to be regarded as highly specialized businesses. In the case of Viking Period and medieval *jernvinna*, there was a range of different degrees of specialization. In some areas, small and isolated sites have been recorded which must be linked to the economic life of individual farms. A different degree is that of, for instance, the JKS tradition in Gausdal,⁴⁴ which is regarded as production for the regional market. The organization involving small sites with charcoal making incorporated within the sites points to autonomous undertakings, with individuals as the agents, although it functioned within a system of regularized commodity exchange.

In the Gråfjell area, I believe that there is evidence of a yet greater degree of specialization. The elements that bear witness to this, according to Costin's model, are:

- *Context*: A business which in my view was indirectly controlled by the royal authority, with economic benefits as a key instrument for stimulated production.
- *Concentration*: The archaeological remains reveal a large-scale activity spread across a large region. There could have been 7,000 bloomeries, 70,000 charcoal pits (blooming sites x 10) and 210,000 roasting sites (charcoal pits x 3) (see Ch. 6, The volume of iron from the Hedmark tradition).
- *Extent*: This is inferred from *concentration*, with the number of sites together with the volume of production giving the quantity.
- *Intensity*: This uncertain variable cannot be presented directly from the evidence available. There is little, however, to suggest that ironmaking was the only means of support. If that had been the case, I think we would find forms of settlement at or close to the blooming sites, as it is unlikely that those participating would have lived a long way from where they worked if this was the only activity they took part in. Ironmaking is thus linked to the settlement we know of, where work followed a cyclical pattern.

As far as organization is concerned, my view is that it was agents linked to the farming society who were responsible for iron extraction in organized teams. *Jernvinna* was not practised under duress or direct orders, and the authorities stimulated production through privileges and benefits. A key point is that the control was located in the distributional system. This is where the goods were channelled and the big profits will have been harvested.

44 Narmo (1996a).

Costin's model clearly shows that the production through the Hedmark tradition involved a high degree of specialization, but it was not, according to that definition, completely specialized, with a full-time working class subject to a king or some authority. The degree of specialization is rather analogous to later industrialization in the stage of development that has been called proto-industrialization (see Ch. 1, *Jernvinna* as an industry?). During industrialization, a proto-industrial intermediary stage was created, at which point the business was neither purely craft nor developed, large-scale industry. The increase in population, the need for profit, and the colonization of new land, were especially important factors in the emergence of proto-industrialization. Together with the development of technology and market commercialization which meant that products became trade goods, this is precisely what characterizes proto-industrialization. The growth of settlement and the development of *jernvinna* in the regular Hedmark tradition quite plainly have a *proto-industrial character*. The migration to the forests of Østerdalen, Solør and north-western Värmland, the colonization of new land with clearly defined boundaries, a steadily rising need for income, the establishment of trading sites, and not least the development of an ironmaking technology with the capacity for large-scale enterprise, are all details that agree with this model. And beyond this, too, there was a form of organization with a high degree of specialization based upon control, mercantile profit, and regional cooperation.

One further detail related to proto-industrialization is crucial in this regard. In studies of major economic complexes, it is essential to study the development in a broad perspective, as the economic historian Sheilagh C. Ogilvie⁴⁵ had indeed pointed out, as there may, for instance, be clear links between proto-industrialization and state-formation. As has been made plain, this study is based on a regional context, but from the early discussions it emerged clearly that there was an obvious co-variation between the development from chieftaincy to kingdom, and the subsequent decline, and the development of *jernvinna* in Hedmark. On this basis, I consider it overwhelmingly probable that *jernvinna* not only had a regional foundation but that it was, by contrast, quite clearly formed by the interplay of factors that accompanied the development of the Norwegian state. This is a point that I shall return to in my conclusions. I shall first, however, go further into how the proto-industrial enterprise was a feature of the society of Østerdalen in the late Viking Period and earlier Middle Ages.

45 Ogilvie (1996) 22–34.

Proto-industrialized Bloomery Ironmaking—the Unknown Economy of Østerdalen

The evidence of bloomery ironmaking implies an economic model which I believe can be classified as an enterprise of proto-industrial character. *Jernvinna*, however, is part of a wider system, and in order to test the relevance of this model it has to be placed in context with its contemporary regional society. In the whole of the study area, settlement was established at the same time as ironmaking was taking shape. Traditional farming settlement dominates the evidence, involving both small farm units and large estate complexes. Additionally, in the Gråfjell area settlements have been found in the forest zones which may have their first dates back in the eighth century. In contrast to the farming settlement in the valley, I believe that this form of settlement shows that there were groups of people who did not support themselves by their own farming. The group was nonetheless fully linked to the agrarian community, as is clearly indicated by the traces of pastoralism, bones of domesticated animals, and a settlement structure derived from Norse farming society. A natural interpretation is that this settlement supported itself through a system in which the people had a subsistence basis composed partially of pastoralism and partly producing goods from resources obtained in the outlying land which they exchanged for grain and other essential agricultural products. How extensive such settlement really was, we do not know, but the ¹⁴C dates and the fact there is a small or medium-sized bloomery site of the Hedmark tradition at or close to many of the shieling sites seems to me to imply that these are more than individual coincidences.

There were, however, four settlement patterns in the area (Fig. 8.3): the regular farming settlement with a greater or lesser basis in cultivation, and a forest settlement, where pasturing and exploitation of outlying land were practised alternately. Both types of farms could be what is termed *fullbonde* and *einvirke*⁴⁶ in the old tax system, but especially forest farms would probably have been smaller units where the latter tax dominated. The third group consists of major farms and landlords that are usually linked to important nodes such as Nes and Glomstad in Åmot and Alfareimr in Elverum. Finally, there are the

46 In the older taxation systems, an *einvirke* ('cotter' or 'cottager') was contrasted with the *fullbonde* ('full farmers'). The full farmer was the man with enough land to require additional help with the labour, while the cotter was the smallholder who only had an additional farm-boy under the age of 15. The cotters also paid less tax, and could be exempted from attendance at the *All-thing* and from other duties.

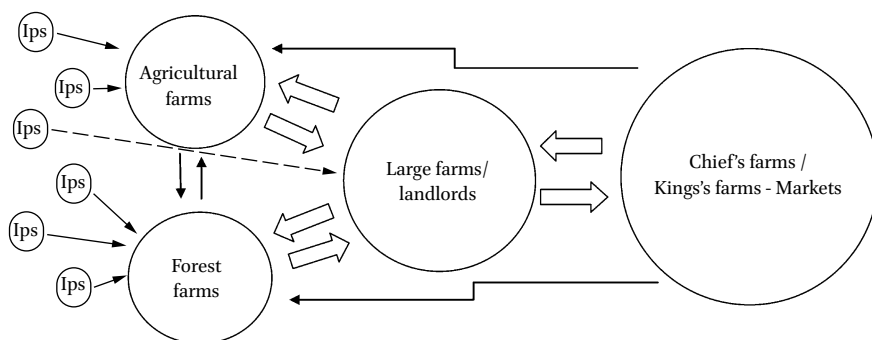


FIGURE 8.3 *Trade and exchange in iron, goods and services in Østerdalen and Solør in the Viking Period and earlier Middle Ages*

BY B. RUNDBERGET, MCH.

chieftains' farms and royal farms, such as the chieftain's seat at Grue and the royal farms of Berg in Stor-Elvdal and Åker on Hedemarken.

The king's farms could have a further stage of development from old chieftainly seats, as at Åker, or they may have been established later, with the purpose of demonstrating presence and controlling the economic activity, like Berg in Stor-Elvdal. These farms were occupied by the king's sheriffs or lieutenants. The major farms had the same role to an extent, as here were landlords or minor chieftains in direct contact with the royal authority or regional chiefs. The major farms were originally established as partly autonomous local power centres where wealth was gathered, as both burial monuments and finds show. The structure of iron extraction shows that the region was part of a larger system, in which the landlords took on a key role within an alliance-based network, over which the chieftains of Solør clearly exercised overlordship. With the transition to the kingdom, the balance of power was gradually relocated and the forest zones from Våler to Stor-Elvdal became the core area of iron production. A movement towards the north is also reflected in the written sources, where Solør loses its pre-eminent role, while the position of the northern region is strengthened through the foundation of the trading sites at Hamar and in Stor-Elvdal, and of royal farms at the same places. Along with the repositioning of the centre of gravity and the penetration of royal power, the role of the landlords changed, as control particularly became a matter of regulating the distribution and exchange of goods.

Those who were active in ironmaking must, as I see it, have been based both in the agrarian farms and the forest farms, and the major farms may also have participated directly. The direct connection between the forest farms and bloomery ironmaking has already been shown. Meanwhile, as well as

undertaking minor ironmaking at the farms or the shielings, the group was also a central element in the major activity. The occupants of the forest farms were dependent upon obtaining agricultural products, particularly grain, by exchange or trade. Through practising bloomery ironmaking as well as livestock farming, they were in an economic position to form part of a trading network.

I regard the settlement involving farming as forming part of the economic system, and probably the largest group, as many of the farm units were not fully self-sufficient in grain. The population of the farms may have taken part in two ways. One was by forming a link within a network, and obtaining both grain and iron by exchange; the other by taking part in ironmaking and so being able to exchange the goods directly. Both are possible, and there is nothing against such economic systems having operated in parallel. Deset and Løsset are the farms closest to the Gråfjell area. Burial monuments and finds, together with *set*-names, imply that these were both cleared in the Viking Period, and Ole Risbøl⁴⁷ believes that it was from these farms, together with the Rødsetra mentioned, that *jernvinna* in the Gråfjell area was undertaken. From its extent, though, many more farms must have participated in this work, and farms along the River Glomma around modern Rena are the most obvious candidates (see Fig. 7.1).

Above these units stood the major farms with their local and regional landlords. By functioning as the practical organ of control over the trading network and distribution, profit was gathered through taxes and tolls on distribution. The major farms were thus an important link before the iron was exported to the trading sites and on out of the region. The basis of this view, for me, lies in the text of the Creed of 1358, where the king granted the right of direct free trade, which was *not*, in my view, an old custom (see Ch. 7, The written sources). This implies that there had previously been a network in which minor chieftains or landlords stood as a link between the iron smelters and the royal authority with their trading posts, because the regional chiefs or the king did not have a good enough infrastructure to exercise this sort of control at a local level. The landlords, however, had been part of wider alliances dependent upon the regional leadership, an alliance that was established as early as was settlement and bloomery ironmaking.

At the top of the regional system was the regional leadership which, in the same way as the group of lesser chieftains, only indirectly influenced production from the outlying land. Written sources show that the king probably controlled the trading sites at Koppang and Hamar, and it was at these places that the big profits must have been made.

47 Risbøl (2008) 278–280.

The economic structure I have suggested corresponds closely with the characteristics of a proto-industrialized economy. The economic activity was not based on an exclusively domestic system but on a partially market-directed society constructed around a redistributive network in which specialized, large-scale *jernvinna* was a fundamental factor. All four links participated in the production, either through direct participation in production or as indirect, governing or controlling powers.

The regional society also functioned within a partially closed system with clearly defined, although shifting, borders. The border was established at the same time as the great forest areas were settled and colonized, and when the Hedmark tradition developed. The potential of bloomery ironmaking must have been grasped early, not least because there was a growing demand for iron in external markets. As the region had developed a technological method well suited to large-scale work, it was important to keep production within those areas which the chieftains and later the king managed. As well as the boundaries possibly being derivative of the use of resources discussed and the mental processes of identity-creation in contrast to outsiders, there was also a purely political and economic dimension, in that the borders became significant in keeping the production inside its own domain. This aspect is reflected in the evidence in two places, albeit in different ways. Production according to the Hedmark tradition became established in Värmland no later than the Viking Period. However, it came to a relatively abrupt end in the middle of the twelfth century (see Ch. 5) after the region finally became Swedish. Those who were responsible for production in this area were part of the existing economic system in Solør and Østerdalen. But when the network was ruptured through the fixing of the national border it was not possible to maintain a form of iron production without some new network being established. That this did not happen must be linked to the fact that the organ of control, with the Norwegian king at the top, was based in Norway. Those who took part in the iron-making themselves had little direct connection with the market, and so it was impossible to sustain the business.

In Hamar, a different development took place. Hedemarken was seriously affected by the civil wars of the twelfth and thirteenth centuries, resulting in instability and continual changes of power. After the episcopal see was founded in 1152/53, the Church gradually gained greater influence in the second half of the twelfth century. Ever more land was subject to the Church, and the trading activity at Hamar was affected by its presence. As a result of these events, the earlier very strong chieftainly and royal power was diminished, a trend that becomes manifest when the king and his close associates virtually disappear from the written sources in the course of the thirteenth century.

This development is quite remarkable in view of the fact that the trading site at Hamar was a central node for trade in iron products from the forests of the east. The development is less remarkable if it was part of a controlled political process, as I believe. The Church became a major power, and in the political power game the king could accept such a change as long as he did not lose control of the great outlying resources. bloomery ironmaking continued to be a major business for much of the thirteenth century, but with the Church having become the major power at Hamar, the iron started to take new routes. Iron may have been exchanged in the trading site of Hamar, but this was probably iron produced in Gausdal. As the somewhat later sources show, it was actually copper-working that was the most prominent metal trade after the Church gained power.

A probable agreement which may form the basis of the change of power in the trading site of Hamar was that the royal authority was willing to give up control of the market site to the Church, but the forest of Hedemarken, and its resources, were to stay under the king as commonland. The Church, for its part, took over much of the wide agricultural land of the Mjøs region, and it was from activity there that its great income was derived, through tithing and trade. This meant, however, that the king had to find new trade routes for the iron, and or to restructure what was already established. An existing trading site was *Kaupangr* in Østerdalen, and some of the iron may have gone there. But it is probable that other trading sites played a role too. One of these may have been Torge, a possible trading site at Hernes north of Elverum, which is believed to have roots back to the prehistoric period.⁴⁸ This trading site is closely linked to Trysil, and it is also through here that Hedemarken was part of its trading complex. As Inga Serning⁴⁹ points out, there were also trade routes to the east through Dalarne to eastern Sweden. Blindheim⁵⁰ focused upon Åker, and suggested that the similarity in finds and grave mounds of the Viking Period shows that this east–west route was an important artery for the Viking kings of Vang. She also suggested that there had been trade routes linking Skiringssal and Birka, a route that both Solør and Elverum would have been part of. Thus an east–west connection was established at Torge just as at *Kaupangr* in Stor-Elvdal.⁵¹ It was certainly a blow to the king to have to give Hamar up as a trading site, but from the trade routes and networks discussed

48 Smith (1784 [1966]); Finne-Grønn (1921) 266–268; Østmo (2000) 55.

49 Serning (1966) 112.

50 Blindheim (1984) 54.

51 Blindheim et al. (1999) 151.

here, and the fact that he continued to control the resources of the outlying land, it is not certain that a political loss of this kind was all that decisive.

Both events, in my view, confirm the important place of iron production, while they also clearly show that ironmaking was firmly integrated into comprehensive social changes of the High Middle Ages. Its role in a society that produced a huge surplus and had a stable redistributive economic system with clearly defined borders is what I would call a proto-industrial landscape, and portrays a dimension of bloomery ironmaking that has not previously been suggested for Norway. The closest to it is ironmaking in Trøndelag in the Roman Iron Age, but production here is believed to have been subject to an alliance of chieftainly centres⁵² rather than to a sole authority. Another difference is that ironmaking in Trøndelag took place at 400–500 sites, while there may have been as many as 7,000 sites, large and small, of the Hedmark type. There is further the colossal number of charcoal pits, probably 70,000, which really highlights just how extensive this business was. In my calculations, I have operated with a proposed figure of 130,000 tonnes of iron before loss through consolidation and smithing, a huge figure, which is only exceptionally found in European evidence.⁵³ This production lasted through a 600-year period, of which the first 250 years saw limited production associated with the southern and eastern parts of the region. Not until close to the end of the eleventh century did production rise significantly. From the figures in the Gråfjell area, as much as 75–80% of the iron was produced in the period 1100–1250, a phase of 150 years. A question which follows, quite naturally, is where this massive amount of iron went. In the final section I shall try to bring out some lines of argument concerned with this question, but before I do so, it remains to discuss a key issue: the reason why production was killed off.

De-industrialization—the Collapse of the Tradition

In the course of a short period of time late in the thirteenth century, the intensive bloomery activity in Hedmark came to an end—swiftly, and more or less at the same time over a great area. In accordance with the proto-industrialization model, this is described as ‘de-industrialization’. At this time, large-scale bloomery ironmaking had been carried on following the same principles for 350 years, with an earlier phase of development of about 250 years. After the tradition achieved its final form in the tenth century, there is no sign of further

52 Stenvik (1996).

53 Magnusson (1986) 273, tab. 33; Englund (2002) 287, tab. 15.

technological development or organizational restructuring. The Hedmark tradition thus did *not* develop into a more industrialized enterprise by bringing technological innovations such as water power or larger furnaces into use. The blast furnace production that was developed in the Swedish Bergslag did not appear either, here or anywhere else in Norway until the fifteenth to seventeenth centuries.⁵⁴ After the Hedmark tradition achieved full development, it was a growing number of sites and participants which led to steadily more intensive activity. This also meant that the economic system likewise underwent no fundamental change apart from more people being involved and greater pressure on trade-related transport and on those who were in control of the network. The politically redistributive network was nonetheless maintained in its ready-made and fully functional form, until it was effectively laid flat. I shall consider possible explanations of that development in what follows.

Looked at in isolation, there could be many reasons for the collapse of a technology or economic systems. In the proto-industrial model, typical explanations are availability of labour, loss of markets, internal or external political change, change in social structure, or the loss of resources and raw materials. This is similar to the usual explanatory models for the collapse of *jernvinna*, in which ecological and demographic models chart the course. Typical of the ecological explanations is that the intensive exploitation of resources ended in a lack of ore or timber. Espelund⁵⁵ believes, for instance, that good bog ore is a non-renewable resource that had formed over the millennia following the last Ice Age. This view implies that the ore resources ran out at a certain point. It is possible that this is correct for some areas, but in the Gråfjell area there are still huge reserves of ore in the form of thick layers of granular ore in the hillside bogs where intense roasting activity has been revealed. I take it as certain that the massive stocks of ore that remain in the Gråfjell area have not been formed only in the last seven centuries. From what I have seen by inspection, this is a view that holds as well in the rest of the study area.

As discussed already, *jernvinna* did put pressure on the woodland resources. As some have pointed out, one question is whether deforestation came to create a resource crisis.⁵⁶ It is clear that there must have been a degree of pressure, and, as I have already pointed out, the use of resources may have led to dynamic exploitation between the activities. That a lack of woodland was a direct cause of de-industrialization is less plausible, at least in the enormous forest

54 E.g. Thuesen (1977); Tveiten (2015).

55 Espelund (2005) 160–161.

56 E.g. Hohle (1993) 5–6.

zones where the Hedmark tradition operated. A.B. Johansen⁵⁷ has pointed out that limited woodland resources in the border zone of the tree line in Ustedalalen may have been a factor in the abandonment of ironmaking in the upper zones. Regrowth is so sparse here that even activity over long cycles could be difficult. Through the Dokka studies, Larsen⁵⁸ found that pine was the only resource in the Roman Iron Age, and in the first period when tapping technology was brought into use. Subsequently, birch was used too, and eventually became the sole fuel. This, in Larsen's view, may be linked to the fact that pine was preferred to start with, but because of its heavy use it eventually disappeared. This did not lead to a reduction or the collapse of production, however, but rather to a change in the use of resources, bringing birch into use.

In Sweden, the forest as a resource for *jernvinna* has been discussed in several contexts and in several regions. In his doctoral thesis on *jernvinna* in Jämtland, Magnusson⁵⁹ concluded that there was never any crisis. The total volume of the forest in Jämtland and Härjedalen is 257,000,000 m³. With 600 recorded sites, he understands that the resources required never once exceeded annual growth. In southern Norrland⁶⁰ and in the Swedish Bergslag at Ludvika, Dalarne,⁶¹ pollen analyses have shown that *jernvinna* was practised alternately with swidden agriculture in the Middle Ages. Both activities require large woodland resources but were nonetheless entirely sustainable side-by-side. This also indicates that the pressure on the forest was not critical. Only when the blast furnace industry was intensified in the seventeenth century did greater pressure on the woodland resources come about, through the work itself but also from the increased population which needed farming and pastureland.⁶² No comparable investigations have been carried out in my study area, but from the basic resources and growth, I consider it improbable that a lack of timber could in any way have led to the collapse of production.

Demographic models are linked primarily to the decline caused by the Black Death, and it is largely earlier scholarship that has suggested this as a cause. In Hedmark, the decline of the tradition lies more than 70 years before the major demographic crisis following the Black Death, and likewise when we look at Norway as a whole we see that production was abandoned both

57 Johansen (1974) 15–19.

58 Larsen (1991).

59 Magnusson (1986) 241; (1997) 34.

60 Magnusson and Segerström (2009).

61 Emanuelsson (2001); Emanuelsson and Segerström (2001).

62 Emanuelsson and Segerström (2001) 16–17.

before and after the wave of plague.⁶³ It is difficult, as a result, to associate this demographic decline with the collapse of *jernvinna*. A different demographic change, however, is the rise in population which eastern Norway experienced in the Middle Ages.⁶⁴ An increase in the population level may have been a motive for further migration into areas with small numbers of people, such as Østerdalen. This may in turn have led to new labour being introduced to production. The growth in the flow of production in the High Middle Ages might therefore be explained in this way. However, this growth could equally have been a contributory factor in the lack of development in the technology itself, and thus a contributory factor in why, in the end, *jernvinna* collapsed.

Nonetheless, population growth did not lead to the decline of ironmaking on its own. The driving forces that led to the demise of the Hedmark tradition should in my view primarily be looked for in the internal and external, socio-political and economic circumstances. In Chapter 7, The written sources, I discussed two internal political explanations in the context of the Decree of 1358. Solem⁶⁵ took the view that the privilege points back to a narrowing of the rights to resources, while Tveiten⁶⁶ has interpreted the Decree as a step in a process following earlier restrictions on distribution by the king. Both cases mistakenly postulate a wish for tighter political control which is supposed to have led to the collapse of *jernvinna*. As I see it, though, there is no evidence in the sources which implies that there were changes in the politics of the economy for a period of 350 years. This indicates that the Hedmark tradition was a successful proto-industrial undertaking. I also believe it is scarcely credible that the royal power would heedlessly change a well-oiled and deep-rooted economic system that had proved itself over generations. For this reason, I consider interpretations involving tighter economic politics to be implausible. This means, too, that the Hedmark tradition collapsed as a practice without the king having been a catalyst in any direct way. For this reason, it is rather more reasonable to look for external circumstances as the governing factors for its demise.

The homogeneity of the evidence for *jernvinna* throughout a long period of time is a clear indicator of a low level of change and thus of a functioning system. At the same time, it shows us the greatest weakness of the proto-industrial enterprise. The Hedmark tradition had become a virtually static system, without room for technological development. A continuous supply of labour was, for a long time, a factor which stimulated greater activity and profit. As long as

63 Larsen (2009) 55.

64 E.g. Moseng et al. (1999) 222–225.

65 Solem (2003) 264–265.

66 Tveiten (2010) 250.

the product was good and competitive, while external markets continued to call for iron, the business kept going. If, on the other hand, new and more effective technologies and/or networks were developed, and the markets collapsed, the activity is very vulnerable. This is the context that I consider will explain its disappearance for the most part.

The Norwegian state was at its strongest in the early fourteenth century, and recent scholarship reveals an expansion in the fields of jurisdiction, administration, military infrastructure and taxation in the years leading up to 1350.⁶⁷ The source of income was at its maximum in the second half of the thirteenth and the early fourteenth century, with tax, land rent and the profits of justice considered to be the principal revenues.⁶⁸ The income is thought to have been very low compared with Sweden and Denmark, and the question has been posed as to how the Norwegian kingship could have been in a position to undertake and put into practice the politics it did in the thirteenth century. The historian Ole Georg Moseng and his co-authors⁶⁹ write that some of the explanation may lie in the activity concerned with the neighbouring countries. In the period 1284–1310, the *leidang*⁷⁰ was called out nearly every other year, and in their view the economic value together with the profits from expeditions, particularly against Denmark, and one-off gains, could have been a crucial economic matter for the king.

Income from other economic activities has not been attributed any great degree of importance. Krag emphasizes the trading of iron in the Viking Period. Sigurðsson takes a similar position,⁷¹ but iron is otherwise little regarded as a source of income by historians. Moseng et al.⁷² virtually go in the opposite direction, believing, amongst other things, that, before the time of the ironworks, *jernvinna* did not have the capacity to produce more than small amounts of iron. They do stress that bloomery ironmaking became more widespread in the Late Iron Age, but link production essentially to the scope for expansion of settlement when there was access to better tools and weapons⁷³ and to farming and self-sufficiency.⁷⁴

67 Moseng et al. (1999) 168.

68 Helle (1993) 193–199; Moseng et al. (1999) 207–209.

69 Moseng et al. (1999) 209–210.

70 An institution known as *leiðangr* (Old Norse), which was a form of conscription to organize coastal fleets for seasonal excursions and in defence of the realm typical for medieval Scandinavians and, later, a public levy of free farmers.

71 Krag (1999) 48–49.

72 Moseng et al. (1999) 392–393.

73 Moseng et al. (1999) 28.

74 Moseng et al. (1999) 38.

The archaeological remains of bloomery ironmaking and hunting over much of the country, as in Hedmark, demonstrate, on the contrary, that this economic element must have had a crucial role. I am also of the view that the king received a great deal of income from these activities, and that the development of High Medieval society is to some extent to be explained on this basis. Moseng et al.,⁷⁵ like Krag, also pay attention to iron as a trade good at Skiringssal in the Viking Period, and in Oslo and Tønsberg in the Middle Ages.⁷⁶ Furthermore, in some cases iron was used to make up land rent⁷⁷ or as currency,⁷⁸ as Gullbekk⁷⁹ has stressed too, in his study of the role of money in the Middle Ages. Although iron is assessed as a trade good, however, it is not considered to have played any greater economic role.

I believe that this needs to be reconsidered, because, along with other resources of the outlying land, iron was an important playing piece in the political game that was played in the High Middle Ages. Iron, therefore, was a key issue in the politics of trade. Several scholars⁸⁰ point specifically to the foreign policy activity of the later thirteenth century as a mistaken strategy, the result of which was negative for Norway's overseas trade. This is shown by comparing Magnus Lawmender and the later regencies of Erik and Håkon v Magnusson. When he was ruling, Magnus prioritized diplomacy and the avoidance of confrontation with Denmark and the Hanse. In 1278, Magnus Lawmender confirmed the Hanseatic merchants' right to trade in Norway. After the regency took power in the 1280, the policy was more assertive, and led to conflicts with the Hanse. In 1282, restrictions were introduced and in 1284, German property in Bergen was confiscated. The Hanse responded with piracy and blockading, and in the end, following arbitration, the Germans had all their rights restored. After King Håkon v came to power in 1299, a new, more national, trade policy was followed, one objective of which was to concentrate trade in the towns in order to control the trade of foreigners and to protect the trading of Norwegians.

That these events had an effect on trade in iron has to be considered likely, as the political events led to ruptures of the networks and trade routes. Since, however, the decline of *jernvinna* in Hedmark began before 1280, and in the 1240s in fact, under Håkon Håkonsson, an assertive foreign policy had been

75 Moseng et al. (1999) 95.

76 Moseng et al. (1999) 244.

77 Moseng et al. (1999) 228.

78 Moseng et al. (1999) 233.

79 Gullbekk (2009).

80 Helle (1993) 253; Krag (2000) 195–196.

pursued,⁸¹ I do not believe that the trade policy can have been decisive and the sole factor in this negative development. The probable connection between these events is that the political trade conflict hastened the decline: it cannot have been its cause.

One can indeed turn the relationship on its head, and suggest that the iron-making in Hedmark may have been one of several factors that precipitated the conflicts at the end of the thirteenth century. As, in the course of the thirteenth century, the Crown lost considerable income from trade in iron, it became essential to improve and to protect other sources of income. In the case of the Hedmark tradition, its disappearance at the end of the thirteenth century is also perhaps to be linked directly to King Magnus's more or less personal control of bloomery ironmaking in Hedmark. There is a visible decline in production from the 1250s, but the date of the final collapse may be associated with this direct relationship, and the connection that was broken when he died.

Jernvinna and the iron produced may thus have been an important basis for, and a contributory factor in, the policy of the regency at the end of the thirteenth century: an urgent need for new sources of income following the loss of an absolutely vital source of income. In this way, the end of *jernvinna* cannot in any circumstances have been the passive result of internal political dealings, but rather a partial cause of the development that led to the fall of the Norwegian kingdom in the fourteenth century.

The reason for the collapse of ironmaking in Hedmark is not explained by these events, and I believe, therefore, that the causes lie in inter-regional circumstances. In this regard, there is one particular factor which I consider was fundamental: the greater competitiveness of cheaper iron. The source of that was probably the growing output of 'Osmond' iron from Bergslag areas of Sweden,⁸² where it is calculated that one could increase production per furnace at least tenfold in comparison with the smelting process.⁸³ Osmond iron is first referred to in England in 1280, but it is thought to have an earlier origin. Osmond iron was a rectangular iron ingot for trading which was produced in the early blast furnaces in the Bergslag. An Osmond weighed around 300 g and the iron bars was exported in barrels to much of Europe.⁸⁴ The date of inception keeps being moved back in time, and the most recent research has found evidence of ore crushing in the eleventh century.⁸⁵ It was not, however, until the end of the twelfth century that this enterprise really took shape, in

81 Moseng et al. (1999) 156–157.

82 E.g. Magnusson (1985); Björkenstam (1995); Pettersson Jensen (2002); Karlsson (2010).

83 Magnusson (1997) 40.

84 E.g. Falck-Muus (1932); Magnusson (1998); Karlsson (2010).

85 Segerström et al. (2010).

the area of Nordberg. In other areas of the Bergslag, the activity goes back to the thirteenth century, but it is primarily from the fourteenth and fifteenth centuries.⁸⁶

Under the project *Järnet och riksbildningen 1150–1350*,⁸⁷ the iron and iron production in the Bergslag areas are emphasized as key to the establishment of the Swedish kingdom.⁸⁸ In the centre stands the technological development of the blast furnace, representing qualitative and quantitative improvements. At the same time occurred the great growth of a free and property-less labour force, which made large-scale production possible.⁸⁹ This iron production did not affect Sweden alone, however; it meant that the international market was plentifully supplied with cheap iron. England has already been referred to, and likewise the German expansion east of the Elbe and the growth of the Hanseatic League are regarded as important markets for the Swedish iron.⁹⁰ This means that the establishment of a new technology and a trading network for iron from the Swedish Bergslag as a new, cheap commodity led to the then aged and static bloomery ironmaking of southern Hedmark no longer being viable. After the mining industry was established, there was quite a swift de-industrialization of the Hedmark tradition, and a 600-year era was over.

More than half a century later, in 1358, Håkon VI Magnusson issued the Decree for Østerdalen. Much has been said about its contents already, but the reason for the king's desire to re-establish what was already a thing of the past is less clear. It is evident that there was an economic motive. The remains of bloomery ironmaking in Hedmark show perfectly clearly that it was an enterprise that exceeded local and regional consumption, and which was directed at the demand of external markets. The sources show, at the same time, that the production was controlled, not only at the point of production but also in the stages of distribution and trade. This is similarly shown by the Decree, where the king offers privileges that the population had not previously enjoyed. Two key questions follow: for whom was the Decree intended, and why was it issued in 1358?

It is evident that Østerdalen had been severely affected by the waves of plague. Studies of deserted farms⁹¹ show that up to two-thirds of the farms were abandoned. It is difficult, as a result, to imagine the surviving population

86 Pettersson Jensen and Karlsson (2010) 256–257.

87 Iron and the formation of the state 1150–1350.

88 Magnusson (2010a).

89 Berglund (2010) 9–11.

90 Lindkvist (2010) 39.

91 Sørensen (1980); Sørensen (1981) Sørensen (1999).

resuming a large-scale business. They were faced with lack of labour, the loss of production, the collapse of the network, the closed trading sites, and the problem of access to the necessary goods. King Håkon VI focuses on the trading site of Hamar, which at that date may have been the only functioning trading site, even though he allows for alternatives. I find it implausible that the surviving population could have launched any extensive iron extraction and begun to trade in 1358. The people presumably had enough to do to maintain adequate primary production and, as Holm⁹² has pointed out, a new economy based on late, pure, self-sufficiency may have arisen. King Håkon VI was undoubtedly fully aware of that. That he nonetheless produced the Decree shows, in my view, an intense need for income. As Sigurðsson has pointed out,⁹³ the Decree was not only for the population of Østerdalen. The text and its privileges can thus rather be seen as a public relations exercise or advertisement on the king's behalf to increase the population of the area through immigration. As the evidence shows, however, it was a mistaken strategy, as it never led to the re-establishment of *jernvinna*.

The Decree was drawn up a few years after Norway left the union of crowns with Sweden and only three years after Håkon VI became king regnant. The year 1319 is traditionally considered to be the end of Norway as an independent state, although more recent scholarship⁹⁴ has shown, by contrast, that even in this period there was a building up of the Norwegian royal authority, and that Norway and Sweden were governed as two separate kingdoms up to 1330, especially as far as foreign relations were concerned. It is clear, however, that, after Magnus VII Eriksson started to rule, Norway had little influence in foreign affairs and in the administration of its own resources. A number of researchers have pointed out that the intentions of Sweden came first, particularly the desire for expansion into Denmark and the Baltic Sea region, and Norwegian trade interests were sacrificed.⁹⁵ The rebellion of the leading men against King Magnus in the 1330s and the demand to crown Håkon VI as King of Norway in 1343 are best to be seen in this context.⁹⁶ These events, together with the disastrous impact of the plagues, meant that the country had a crying need for income when Håkon did become the regnant king in 1355. Through the union of crowns with Sweden, the leading men and regents must have seen the economic impact of the iron production of the Bergslags for Sweden.

92 Holm (2003).

93 Sigurðsson pers. comm. 18 January 2011.

94 Moseng et al. (1999) 158–165.

95 Hellevik (2004) with refs.

96 Moseng et al. (1999) 160.

On this basis, it is easy to see why Håkon VI considered the possibilities of re-establishing the old business and the chance of creating new trade links. The fact that the king prioritized *jernvinna* in Hedmark may be because it had provided the greatest economic profit from relatively few resources. To establish a production of iron on the Swedish model must, however, have appeared unrealistic in light of the resources of personnel, capital and technological know-how that were available in 1358.

The Economic Role of Iron in an Inter-regional Perspective

The results that have been presented in this book lead to new questions which, it is to be hoped, may be answered by further research. At this point, I shall note some of these, and suggest a course that I consider would be most effective.

A topic that there has been no particular focus on in Norway, unlike, for example, in Sweden and Denmark, is the second refining and manufacturing stage of the process. This lack clearly reflects the fact that this type of manufacturing site is rarely detected. Central to a future study would therefore be the questions of when, where and how the blooms or split-blooms were refined, and what products or semi-finished products have been part of the exchange or economy. These questions must firstly be answered by focusing on the smithies and manufacture processes. Where did the refining stage take place, what was done there and to what extent were the blooms treated (Fig. 9.1). Related to this, the unanswered question of outcome or proportion of loss is important, and whether there was regional variations in the process. Another question is to what extent the processes were executed together or separately by the same or different groups, and whether there was any internal economy between the two activities.

The bloomery ironmaking practice in the Hedmark tradition is different from those of other, contemporary, ironmaking regions, both in technology and in organization. The production was systematically built up and carried out according to a fixed concept and the result was the production of a huge surplus. An essential research project, therefore, would be to study other regions, to gain perspectives on how extensive the production in Hedmark really was. Was the volume much greater than in other regions, or was Hedmark in fact just one of many regions with particularly intensive production, albeit with specific technological and organizational differences? In some regions, relevant questions have been investigated. In Gausdal, Narmo has concluded that *jermvinna* was on a scale large enough to meet the region's own needs.¹

¹ Narmo (1996a).

The same tradition was subsequently identified in Valdres and Øystre Slidre, and the total extent of production is not yet known. At Møsstrond, Martens believes that 10,000 kg of iron were produced in the period AD 950–1150.² This exceeded local need, and the iron must have been intended for other markets. A region where a few, rather unsophisticated, calculations of yield have been made, but which is ideally suited for such a study, is Bykle, with Hovden as its central area. This region stands out, with much remaining evidence of ironmaking from the late Viking Period and Middle Ages.³ Rolfsen writes that in Bykle and neighbouring parts from Vinje to Haukeligrend there are 1,000 bloomery sites and 14,000 charcoal pits. Several excavations in recent years mean that we now have evidence which could shed light on questions of this kind.

Chronology and chronological variance have been thoroughly examined in this book, and I have focused on how one can use statistical probability calculations on series of radiocarbon dates to narrow and make more precise the period of use of bloomery sites and within larger areas. Here, however, there is potential for further improvement of the results. By using the accelerator method with all ¹⁴C dates the picture will gradually become clearer, with reduced error margins in ages $\pm n$ BP. Another key requirement is better and more detailed studies of wood anatomy in order to determine the time-width of the charcoal.⁴ By undertaking detailed studies of this kind in order to produce the best possible evidence, along with statistical probability calculations, the chronological framework of *jernvinna* will be much more secure in the future.

Importance has been attached to assessments of volume in this work. The principal objective was to put a fairly definite figure to this dimension, and then to map out which periods production was highest in. I have not, however, attached great importance to the relationship between production and demand at local, regional and inter-regional levels. I do, though, regard this question as possibly the most fundamental of all for further research. The problems involved therein are multifaceted. One objective in a future study should be to get an idea of the actual need that the community had. It has already been suggested how much iron a farm uses each year.⁵ That apart, there is practically no

2 Martens (1988) 73.

3 Bloch-Nakkerud (1987); Rolfsen (1992a); Mjærjum (2011).

4 Loftsgarden et al. (2013).

5 E.g. Narmo (1996a).

information on other social needs, such as iron for military levies and expeditions, iron for boatbuilding, iron for church building, iron for agriculture, iron for fishing, etc. There is an example of such a study from France, where an investigation has recently been carried out into the volume of iron and steel that were used in church building.⁶ The figures they produced, and the variation in the quality of iron, are striking, and show that our ideas of demand and market have to be expanded to incorporate much wider perspectives than farming alone. If one is to understand the dynamics between production, demand, market, trade and consumption, analyses of this kind need to be undertaken in Norway too.

Taking such a study further, one should focus on external markets. An example of this is Denmark, which remains practically bereft of known iron extraction in the Viking Period and Middle Ages. However, other regions such as Britain and north-central Europe also have little documented production later in the 1st and early in the 2nd millennia AD. This is a large and active area, with regions that needed huge amounts of new iron for tools, building and warfare. In a dissertation on urbanization in Denmark, the historian Jørgen Elsøe Jensen⁷ considered that arable farming and its agriculture were the preconditions for urbanization in the period AD 1150–1225. From calculations of how much land was cleared and ploughed,⁸ and through experimental tests of the wear of ploughs, Jensen postulates that 500 t of iron were needed each year in Denmark for ploughing alone. An important aspect of this work is that it focuses on the consumption and need for iron on a larger scale, and that Denmark emerges as a region with a massive need to import iron. Recently, a Swedish archaeologist, Catarina Karlsson, has also discussed the requirement for iron as part of the agricultural expansion in Sweden in the Middle Ages. Also, here, the focus has been on consumption, based on wear of ploughs.⁹

Trade or exchange involving iron are closely interwoven with external demand and an internal demand for other goods. What the trade routes were like, however, is a neglected subject. Loftsgarden¹⁰ has looked at trade routes and networks in Rauland and Møsstrand in Telemark. He attaches importance to

6 L'Heritier, Dillmann and Benoit (2010).

7 Jensen (2010) 17.

8 Myrdal (1999) 53–59.

9 Karlsson (2015).

10 Loftsgarden (2007), (2011).

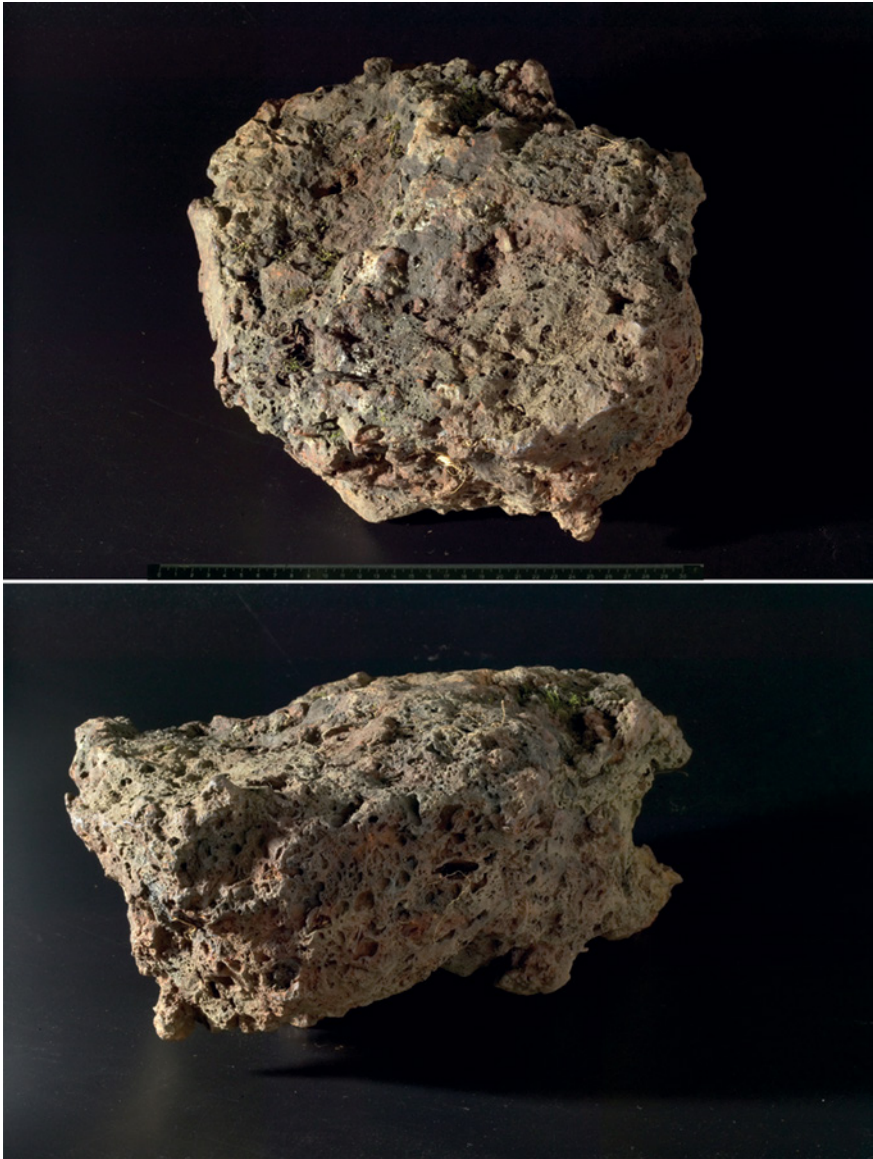


FIGURE 9.1 A 19 kg iron bloom found beside a hollow way in the Gråfjell area. Metallurgical analyses show that the surface was worked to a degree and consolidated immediately after removal from the furnace. The bloom contains little slag and consists of soft iron, albeit with some more carbon-rich pockets (Grandin et al. (2006); Espelund (2009b)). A possible interpretation of the find context is that the bloom was lost during transport, which may have been to a smithy or to a market place.

PHOTO: M. TEIGEN, MCH.



FIGURE 9.2 12 axe blanks strung on a spruce rod found at Granå in Jutland. This find indicates that there was trade in iron between Norway and Denmark in the Viking Period and Middle Ages, after Krag (1995) 205.

the fact that the farms in a stable society could undertake ironmaking as a supplementary activity, with a view to exchange for goods, and that it is likely that the iron followed the same trade routes as the whetstones from Eidsborg—i.e. the Telemark watercourse to Skien. Similar studies need to be undertaken elsewhere, including in Hedmark. The trading sites show that the iron may have gone north, east and southwards. A western route appears less likely as there was quite extensive production already in those areas, which would presumably have covered any such routes. Deeper studies concerned with trade and trade routes, and with products for trade identified in accordance with the studies referred to above, are thus an important task for future research. There is a small amount of evidence concerning iron as a traded commodity. In Norway, we also have a number of finds of iron bars, although their provenance and date as a body of evidence remain uncertain. An exciting find in terms of super-regional trade is the axe blanks that were found near Grenå in Denmark in 1949.¹¹ This find consisted of 12 semi-manufactured pieces that were strung on a sprucewood bar (Fig. 9.2). The iron was probably produced in Norway¹² and pertains to trading contact between Norway and Denmark from the Viking Period and Middle Ages.¹³

Where Viking Period and medieval iron in Norway comes from, and what hinterlands the various regions had, are very important questions. Hedmark has been discussed in this study, but in a wider study other regions should be included. One issue is that, although ironmaking disappeared from

¹¹ Thorvildsen (1950).

¹² Espelund (2005), 90.

¹³ Rundberget (2015).

Hedmark just before AD 1300, production in Gausdal continued well into the fourteenth century. At Hovden, production carried on into the fifteenth century. This is probably a result of the regions of *jernvinna* being associated with different networks, in which needs and access varied both spatially and temporally. Through the project 'Iron Origin'¹⁴ an attempt is being made to shed light on these problems. The project has as its starting point the aim to investigate the degree to which chemical variation in ore, slag and iron is systematic and site-specific: if it is possible to determine the provenance of iron artefacts; to map eastern Norway with respect to the chemical composition of ore and slag; and to develop 'best practice' for identifying the chemical signatures of ore, slag and iron from various regions of south-east Norway.¹⁵ The aim is to develop the project further so as to cover more of the country. Provisional results suggest that exhaustive chemical analyses can shed light on this matter, as regions that are already part of the study do reveal different signatures. However, there are also wide fluctuations within regions, for instance in the Gråfjell area,¹⁶ and a primary challenge must be to collect large amounts of data, both from slag from bloomery sites and from artefacts, in order to create a statistically satisfactory basis for reaching conclusions.

This study has its roots in a collection of archaeological bulk evidence, and it is through that, primarily, that I have attempted to shed light on definite issues concerned with technology, organization, regional patterns, volume and chronological sequence. An important approach, however, has also been to incorporate other archaeological and historical sources. I have shown that the 'historical truth' concerning what was the key economic precondition for the development—agriculture—was probably not so uniquely determinative as scholarship has assumed hitherto. Documentary sources shed very little light on the resources of the outlying land and on bloomery ironmaking, but I have a clear understanding that the evidence, both the archaeological and the historical, is able to provide indirect information on undescribed events when it is put in context with other sources of evidence, and ideally in a local or regional context. This holds for archaeological research in periods for which we have documentary sources. Without access to the written sources, it would have been impossible to answer the questions in this study to the extent that has

14 <http://www.khm.uio.no/english/research/projects/gokstad/>.

15 Larsen et al. (2011); Grandin et al. (In press, 2017).

16 Grandin et al. (2006); Rundberget (2007).

now been achieved. For this reason, it is crucial for future research to establish wider cooperation between disciplinary branches than exists at present. The result one could expect from that, will undoubtedly be the generation of new perspectives on society and social development in Norway in the Late Iron Age and Middle Ages.

Appendices

APPENDIX 1A Bloomery sites excavated in the Gräffell area—data and interpretation

Site No.	Model	Numb.	Name	Form	Slag heaps			
					Measure (m)	Hight (m)	Volume (m3)	Distance (m)
<i>Jfp.1</i>	<i>Standard</i>	3	SH1	Oval	8,3 × 4,2	0.9	18.7	
			SH2					
			Slagg waste					
<i>Jfp.2</i>	<i>Standard</i>	2	SH1	Oval	5,8 × 4,0	0.5	4.6	6.5
			SH2	Oval	6,5 × 3,9	0.3	2.4	
<i>Jfp.3 (1)</i>	<i>Standard</i>	2	SH1	Oval	6,6 × 4,5	0.7	5.5	6.5
			SH2	Round	5,6 × 4,5	0.6	4.7	
<i>Jfp.3 (2)</i>	<i>Standard</i>	2	SH3	Smeared	5,8 × 5,6	0.2	—	6
			SH4	Smeared	5,5 × 5,2	0.2	—	
<i>Jfp.4</i>	<i>Basic</i>	1	Slag waste	Smeared	6,8 × 4,0	0.3	6	—
<i>Jfp.5 (1)</i>	<i>Basic and standard</i>	4	SH3	Oblong	5,7 × 4,5	0.6	4.5	
			SH4	Round	4,5 × 3,1	0.8	2.6	
			SH5	Smeared	5,5 × 2,0	—	1.2	
			SH6	Round	4,0 × 3,5	—	<1	
<i>Jfp.5 (2)</i>		2	SH1	Oblong	8,0 × 6,0	0.9	14.1	7.2
			SH2	Oblong	6,5 × 4,3	0.7	1.1	
<i>Jfp.6</i>	<i>Variation standard</i>	2	SH1	Oblong	7,1 × 3,1	0.5	7.1	On line
			SH2	Round	5,4 × 4,8	0.3	5	

Site No.	Charcoal stockpile					Ore stockpile				
	Numb.	Name	Form	Measure (m)	Thickness (cm)	Numb	Name	Form	Measure (m)	Thickness (cm)
<i>Jfp.1</i>	2	Cs 1	Unsure	10,0 × 4,0	12	2	Os 1	Oval	8,0 × 4,0	6
		Cs 2	Rectangular	2,5 × 1,3	10		Os 2	–	–	6
<i>Jfp.2</i>	1	Cs	Oblong	5,0 × 2,8	8	1	Os	Nearly round	9,0 × 8,1	12
<i>Jfp.3 (1)</i>	1	Cs	Oblong	4,8 × 3,8	2 til 4	2	Os 1	Irregular	2,0 × 1,3	2 to 5
							Os 2	Irregular	2,5 × 3,0	4
<i>Jfp.3 (2)</i>	1	Cs	Square	3,3 × 2,7	4	1	Os	Rectangular	1,8 × 1,7	4
<i>Jfp.4 (1)</i>	3	Cs 1	oblong	6,1 × 5	14	4	Os	Smeared	5,8 × 5,6	1 to 5
		Cs2	Round	Diam. 1,1	2		Os/Rp	Oblong	4,3 × 2,0	7 cm
		Cs3	Rectangular	5,0 × 3,7	15		Os 2	Oblong	4,8 × 3,8	20
		Cs4	Trapes	4,6 × 3,7	20		Os 3	Rectangular	2,8 × 2,2	15
		Cs5	Oval	3,0 × 1,9	10		Os 5	Oval	2,0 × 1,8	10
<i>Jfp.5 (2)</i>	2	Cs 1	Rectangular	4,8 × 3,6	3 to 15	2	Os 6	Square	2,4 × 1,4	5
		Cs 2	Square	4,0 × 2,8	15		Os 1	Smeared	4,1 × 3,6	10 to 15
<i>Jfp.6</i>	3	Cs 1	Rectangular	4,8 × 4,6	5	3	Os 4	Rectangular	3,6 × 2,8	2 to 10
		Cs 2	Rectangular	1,4 × 1,2	5		Os 1	Square	2,2 × 1,9	12
		Cs 3	Rectangular	2,0 × 1,7	15		Os 2	Rectangular	2,7 × 5,0	10
							Os/Rp	Rectangular	5,7 × 3,0	15

APPENDIX 1A *Bloomery sites excavated in the Gråfjell area—data and interpretation (cont.)*

Slag heaps								
Site No.	Model	Numb.	Name	Form	Measure (m)	Hight (m)	Volume (m ³)	Distance (m)
<i>Jfp.7</i>	<i>Basic</i>	1	Slag waste	Nearly round	Diam. 3,0	0.25	1.5	—
<i>Jfp.8</i>	<i>Basic and standard</i>	4	SH1	Oval	5,6 × 4,4	0.6	4.7	
			SH2	Oblong	3,0 × 2,0	0.3	6,5	SH1-SH4: 9,6
							SH2 + SH4	
			SH3	Oblong	5,3 × 4,8	0.4	2.9	SH1-SH2: 6,2
			SH4	Irregular	5,1 × 6,0	0.25	6,5	SH2 + SH4
<i>Jfp.9 (1)</i>	<i>Standard</i>	2	SH1	Oval	9,8 × 5,5	1	14.3	5
			SH2	Oval	6,0 × 3,8	0.34	4.8	
<i>Jfp.9 (2)</i>	<i>Standard</i>	2	Slag waste	Round	5,2 × 5,5	0.35	—	Embankments-slag wastes: 5
			Embankment	Smeared	2,5 × 2,3	0.15	—	
			Embankment	Smeared	2,4 × 1,7	0.15		
<i>Jfp.10</i>	<i>Basic</i>	1	Slag waste	Oval	7,0 × 4,5	0.5	5	—
<i>Jfp.11</i>	<i>Standard</i>	2	SH1	Oblong	6,7 × 2,5	0.3	1.7	4.2
			Two slag wastes	Oval	2,0 × 0,7	0.15	—	
				Oval	2,0 × 1,5	0.1	—	
<i>Jfp.12 (1)</i>	<i>Basic and standard</i>	4	Slag waste	Round	4,0 × 3,5	0.25	1.5	
			SH1	Oblong	8,7 × 4,3	0.8	11.6	SH1-SH2: 10
			SH2	Oval	9,2 × 5,7	0.9	17.6	
			SH4	Oval	6,4 × 3,5	0.32	6.7	
<i>Jfp.12 (2)</i>		1	SH3	Angel	6,6 × 5,2	0.5	10.6	
<i>Jfp.12 (3)</i>		1	Slag waste	Smeared	3,1 × 2,2	0.1	—	
<i>Jfp.13</i>	<i>Standard</i>	2	SH1	Oval	6,3 × 4,7	0.6	5.3	8
			SH2	Round	Diam. 3,6	0.8	2.9	

Charcoal stockpile						Ore stockpile				
Site No.	Numb.	Name	Form	Measure (m)	Thickness (cm)	Numb	Name	Form	Measure (m)	Thickness (cm)
Jfp.7	1	Cs	Round	Diam. 3,5	–	1	Os	Square	1,9 × 2,1	4
Jfp.8	1	Cs	Round	Diam. 5,0	2	1	Os	Oblong	7,0 × 6,5	10
Jfp.9 (1)	2	Cs 1	Smeared	3,1 × 2,3	10	2	Os 1	Round	Diam. 1,5	8
		Cs 2	Rectangular	2,7 × 2,5	12		Os 2	Oblong	3,1 × 2,6	10
Jfp.9 (2)	1	Cs	Square	1,6 × 1,4	4		Os	Smeared	2,7 × 2	7
Jfp.10	1	Cs	Rectangular	9,5 × 5,0	5	1	Os	Rectan- gular	4,2 × 3,6	20
Jfp.11	1	Cs	Square	2,5 × 2,5	3	1	Os/Rp	Rectan- gular	3,3 × 2,0	15
Jfp.12 (1)	4	Cs 1	Rectangular	3,1 × 2,2	10					
		Cs 2	Smeared	2,3 × 1,0	5	2	Os 1	Square	2,7 × 2,4	7
		Cs 3	Round	Diam. 2,0	6		Os 2	Square	Diam. 3,0	5
		Cs 4	Round	Diam. 2,4	8					
Jfp.12 (2)	1	Cs 5	Rectangular	2,7 × 2,0	10	1	Os 3	Smeared	4,0 × 2,0	5
Jfp.12 (3)		Cs 6	Smeared	2,5 × 1,9	9	–	–	–	–	–
Jfp.13		Cs	Oblong	4,0 × 1,4	10	2	Os 1	Square	4,8 × 4,8	5
							Os 2	Smeared	5,0 × 3,4	5 to 10

APPENDIX 1A *Bloomery sites excavated in the Gråfjell area—data and interpretation (cont.)*

Slag heaps								
Site No.	Model	Numb.	Name	Form	Measure (m)	Hight (m)	Volume (m3)	Distance (m)
<i>Jfp.14</i>	<i>Basic and standard</i>	3	SH1	Oblong	11,0 × 6,0	0.9	23.3	
			SH2	Oblong	8,0 × 5,5	1	11.6	SH1-SH2: 6,7
			SH3		6,0 × unknown	0.5	4	
<i>Jfp.15</i>	<i>Standard</i>	2	SH1	Oval	6,6 × 2,3	0.46	0.7	6
			SH2	Oval	5,0 × 3,8		2.5	
<i>Jfp.16</i>	<i>Basic</i>	1	SH	Round	5,5 × 5,1	0.3	3.5	—
<i>Jfp.17</i>	<i>Basic</i>	1	SH	Smeared	5,1 × 4,2	0.15	<1	—
<i>Jfp.18</i>	<i>Variation standard</i>	1	Slag waste	Oblong	2,7 × 1,5	spettet	0.4	—
<i>Jfp.19</i>	<i>Standard</i>	2	SH1	Oblong	7,5 × 4,5	1	10.3	6.4
			SH2	Oblong	7,2 × 5,2	0.7	4.9	
<i>Jfp.20</i>	<i>Standard</i>	2	SH1	Oblong	7,2 × 5,0	1	17	6.5
			SH2	Oblong	7,9 × 5,4	0.8	10	
<i>Jfp.21</i>	<i>Standard</i>		SH1	Oblong	6,0 × 2,5	0.6	—	6
			SH2	Oblong	7,0 × 3,0	—	—	
<i>Jfp.22</i>	<i>Standard</i>	2	SH1	Oval	6,0 × 4,5	0.6	—	7.5
			SH2	Oval	5,0 × 3,0	0.8	—	
<i>Jfp.23</i>	<i>Basic and standard</i>	3	SH1	Oval	7,6 × 5,8	1.4	8.4	
			SH2	Round	6,1 × 5,7	0.3	2	SH2-SH3: 9
			SH3	Oblong	6,1 × 3,1	0.6	1.9	
<i>Jfp.24</i>	<i>Basic</i>	1	SH1	Oblong	6,0 × 4,0	0.8	—	—
<i>Jfp.25</i>	<i>Standard</i>	2	SH1	Oval	7,0 × 3,5	0.6	—	6.5
			SH2	Oval	6,0 × 4,5	1.3	—	
<i>Jfp.26</i>	<i>Standard</i>	2	SH1	Oval	5,5 × 4,5	1.3	—	8.5
			SH2	Angel formed	8,0 × 4,0	0.7	—	
<i>Jfp.27</i>	<i>Standard</i>	2	SH1	Oblong	3,5 × 2,5	0.3	—	SH2 destroyed

Site No.	Charcoal stockpile					Ore stockpile				
	Numb.	Name	Form	Measure (m)	Thickness (cm)	Numb	Name	Form	Measure (m)	Thickness (cm)
<i>Jfp.14</i>	2	Cs 1	Oval	4,5 × 4,3	20	2	Os 1	Rectangular	6,0 × 4,0	20
		Cs 2	Rectangular	3,5 × 2,5	20		Os 2	Smeared	4,0 × 3,0	5
<i>Jfp.15</i>	1	Cs	Square	4,5 × 4,2	4 to 8	1	Os	Smeared	6,0 × 3,0	2
<i>Jfp.16</i>	1	Cs	Square	4,0 × 4,0	5	1	Os	Rectangular	2,9 × 2,0	2
<i>Jfp.17</i>		Cs	Rectangular	2,0 × 1,7	2	1	Os	Smeared	1,2 × 1,5	9
<i>Jfp.18</i>	1	Cs	Oval	3,0 × 2,1	30	1	Os	Oval	2,1 × 1,6	27
<i>Jfp.19</i>	1	Cs	Rectangular	4,5 × 2,8	15	1	Os	Smeared	6,0 × 3,0	8
						3	Os 1	Square	3,8 × 4,2	10
<i>Jfp.20</i>	1	Cs	Oval	6,9 × 2,3	13		Os 2	Smeared	4,5 × 4,7	30
							Os 3	Smeared	4,0 × 3,8	20
<i>Jfp.21</i>	2?	—	—	—	—	1?	—	—	—	—
<i>Jfp.22</i>	1?	—	—	—	—	1?	—	—	—	—
<i>Jfp.23</i>	1	Cs	Smeared	10,0 × 10,0	9	2	Os 1	Smeared	8,5 × 6,0	2 to 7
							Os 2	Smeared	9,0 × 5,0	5 to 20
<i>Jfp.24</i>	1?	—	—	—	—	1?	—	—	—	—
<i>Jfp.25</i>	1?	—	—	—	—	1?	—	—	—	—
<i>Jfp.26</i>	1?	—	—	—	—	1?	—	—	—	—
<i>Jfp.27</i>	?	—	—	—	—	1?	—	—	—	—

APPENDIX 1A *Bloomery sites excavated in the Gråfjell area—data and interpretation (cont.)*

Slag heaps								
Site No.	Model	Numb.	Name	Form	Measure (m)	Hight (m)	Volume (m ³)	Distance (m)
<i>Jfp.28</i>	<i>Standard</i>	2 (3)	SH1	Smeared	1,9 × 1,7	0.13	465,5 kg (veid)	9.2
			SH2	Oval	6,0 × 4,5	0.8	9	Part of same heap
			SH3	Round	3,0 × 2,9	0.4	1	
<i>Jfp.29</i>	<i>Standard</i>	2	SH1	Oblong	7,6 × 4,3	0.5	3	9.5
			SH2	Round	6,2 × 6,0	0.8	4.8	
<i>Jfp.30 (1)</i>	<i>Basic and standard</i>	4	SH1	Oval	8,5 × 6,5	1	12.5	SH1-SH2:9,2
			SH2	Oblong	12,0 × 6,5	1.3	12.6	
<i>Jfp.30 (2)</i>			SH3	Oval	9,8 × 6,0	1.5	19	SH3-SH4:9,3
			SH4	Oblong	8,5 × 3,6	0.6	4.4	
<i>Jfp.31</i>	<i>Standard</i>	2	SH1	Oval	5,2 × 4,4	0.6	4.6	6.6
			SH2	Oval	5,3 × 3,9	0.9	4.8	
<i>Jfp.32</i>	<i>Standard</i>	2	SH1	Oblong	7,8 × 4,6	0.9	7.5	SH1-SH2:7
			SH2	Oblong	9,0 × 5,6	0.7	8	
			Embankment	Round	3,8 × 2,2	0.5	2.1	
<i>Jfp.33</i>	<i>Standard</i>	2	SH1	Oblong	5,7 × 3,1	0.5	3	6
			SH2	Oval	6,0 × 4,0	0.4	3.4	
<i>Jfp.34</i>	<i>Standard</i>	2	SH1	Oblong	5,6 × 3,6	0.6	3.6	5.8
			SH2	Round	2,0 × 2,0	0.3	1.8	
<i>Jfp.35</i>	<i>Basic</i>		SH	Oblong	2,0 × 1,0	—	—	—
<i>Jfp.36</i>	<i>Basic</i>	1	SH1 and SH2	Oblong				same heap

Site No.	Charcoal stockpile					Ore stockpile				
	Numb.	Name	Form	Measure (m)	Thickness (cm)	Numb	Name	Form	Measure (m)	Thickness (cm)
						2	Os 1	Oval	4,0 × 5,0	4 to 5
<i>Jfp.28</i>	1	Cs	Smeared	3,7 × 3,0	10		Os 2	Smeared	1,6 × 1,4	11
<i>Jfp.29</i>	2	Cs 1	Rectangular	5,0 × 4,0	10	2	Os 1	Smeared	10,0 × 4,0	15
		Cs 2	Rectangular	5,5 × 4,0	5		Os 2	Square	4,5 × 4,5	15
<i>Jfp.30</i> (1)	1	Cs 1	Oblong	2,6 × 1,4	10	1	Os 1	Square	4,6 × 5,0	3
<i>Jfp.30</i> (2)	1	Cs2	Rectangular	5,8 × 4,4	30	1	Os 2	Mottled	5,3 × 4,4	2
<i>Jfp.31</i>	2	Cs 1	Smeared	1,7 × 1,8	3	3	Os 1	Rectangular	2,5 × 3,9	5
		Cs 2	Square	2,3 × 2,4	4		Os 2	Smeared	4,0 × 4,0	3
							Os 3	Oval	1,8 × 2,0	2
<i>Jfp.32</i>	2	Cs 1	Rectangular	5,5 × 3,0	6	2	Os 1	Smeared	8,0 × 3,5	10
		Cs 2	Rectangular	6,0 × 4,0	10		Os 2	Square	4,0 × 3,5	10
<i>Jfp.33</i>	1	Cs	Rectangular	3,0 × 5,0	6	2	Os 1	Rectangular	4,0 × 2,6	—
							Os 2	Oblong	2,0 × 2,8	—
<i>Jfp.34</i>	1					1				
<i>Jfp.35</i>	1?	—	—	—	—	1?	—	—	—	—
<i>Jfp.36</i>	1	Cs				1	Os			

APPENDIX 1A *Bloomery sites excavated in the Gråffell area—data and interpretation (cont.)*

Slag heaps								
Site No.	Model	Numb.	Name	Form	Measure (m)	Hight (m)	Volume (m3)	Distance (m)
Jfp.37	Basic and standard	3	SH1	Oval	2,5 × 2,0	—	—	—
			SH2	Oblong	4,3 × 2,5	0.4	—	SH2-SH3: 7,5
			SH3	Oblong	4,6 × 2,6	0.4	—	
Jfp.38	Basic	2	SH1	Round	4,0 × 4,0	—	—	—
Jfp.39	Basic and standard		SH1	Oblong	13,3 × 5,2	0.6	8.4	6.7
			SH2	Oblong	10,7 × 6,4	0.9	11.2	

Charcoal stockpile						Ore stockpile				
Site No.	Numb.	Name	Form	Measure (m)	Thickness (cm)	Numb	Name	Form	Measure (m)	Thickness (cm)
Jfp.37	2	Cs 1	—	—	—	2	Os 1	—	—	—
		Cs 2	—	—	—		Os 2	—	—	—
Jfp.38	1?	—	—	—	—	1?	—	—	—	—
Jfp.39	1	Cs	Rectangular	8,0 × 4,3	2 to 16	2	Os 1	Rectangular	3,6 × 2,1	2 to 7
							Os 2	Oblong	2,6 × 1,3	2 to 7

APPENDIX 1B Excluded bloomery sites, not archaeologically investigated

Id-No.	Description from survey/excavation	Rec. type	Number of SH	Model
Id 1024847	Bloomery site of the 695-type with two parallel slag heaps and tapping slag. Aligned NE–SW. Slag heap furthest NW: length 7.3 m, width 4.6 m, height 0.75 m. Distance between the slag heaps: 7.2 m. Slag heap furthest to SE: length 7.0 m, width 4.7 m, height 0.7 m. / <i>Clear trench alongside the slag heap to the NW and a minor hollow beside the slag heap to the SE. Both are interpreted as furnace zones and tapping channels/pits.</i>	695	2	Standard
Id 1024863	Bloomery site of the 695-type with two parallel slag heaps and tapping slag. The site is aligned N–S. The slag heap furthest to the E: length 8.6 m, width 5.2 m, height 0.9 m. Distance between the slag heaps 6.2 m. The slag heap furthest to the W: length 10.5 m, width 9.1 m, height 0.65 m. The W slag heap is highly amorphous but is not round. Possibly flattened. / <i>Slag heap to W is damaged and makes identification of a possible furnace zone difficult. A minor rise by slag heap to E is probably waste surrounding the furnace. Some charcoal exposed indicates the location of the charcoal stockpile.</i>	695	2	Standard
Id 1024867	Bloomery site of the 695-type with two parallel slag heaps and tapping slag. The site is aligned E–W. The slag heap furthest to the S: length 8.2 m, width 5.2 m, height 0.9 m. Distance between the slag heaps 8 m. The slag heap furthest N: length 8.6 m, width 4.9 m, height 0.94 m. The site is situated on a dry tongue projecting into a wet area. Wheel tracks between the slag heaps from a forestry machine. / <i>The tracks have prevented identification of the furnace zones, but an inconspicuous hollow beside slag heap to the S indicates a tapping channel.</i>	695	2	Standard

Id 1023587	Two parallel slag heaps. Bloomery site of the 695-type. Aligned SE/NW. SW slag heap: 7.7 × 5.2 × 1.1 m. NE slag heap: 6.5 × 4.5 × 0.7 m. Distance between the slag heaps 6.7 m. The site lies immediately NE of a stream. The NE heap is disturbed by site preparation./The site preparation means that slag in the form of tapping cones, tapping plates and pit slag is exposed. This implies technology of the familiar type. No clear sign of the furnace zones.	695	2	Standard
Id 1024712	An oval slag heap of the 695-type (one phase) with tapping slag, aligned E-W. Length 5 m, width 3.5 m, height 0.55 m. 2 m to the N a heap of the 300-type: diameter 2.5 m, height 0.55 m./Distance and size and organization of the heaps implies two phases. A minor hollow S of slag heap to the S indicates that there were also two production zones.	695 + 300	2	Basic + Basic
Id 1024719	Bloomery site of the 695-type with tapping slag, and with two parallel slag heaps aligned E-W. Slag heap to S: length 7.8 m, width 5.8 m, height 1.0. Slag heap to N: length 5.2 m, width 5.2 m, height 0.9 m. At the end of the N slag heap lies a square impression/building, possible a smithy measuring 4.3 × 4 m, height 0.4 m. The banks consist of slag and burnt clay from the furnace. Possible smithy slag. The N slag heap is partially damaged by forestry. Wheel tracks between the heaps./The interpretation as a building is explicitly made on the basis of slag banks composed of forging slag. Depressions run parallel to both the slag heaps. These form tapping channels and show the location of the furnaces.	695	2	Standard

APPENDIX 1B *Excluded bloomery sites, not archaeologically investigated (cont.)*

Id-No.	Description from survey/excavation	Rec. type	Number of SH	Model
Id 1024408	Site with tapping slag and slag lumps with impressions of charcoal. Slag over much of the surface, but four slag heaps can be located: three low parallel ones, aligned E-W (with slag in between them). A larger oblong heap to the W aligned N-S: length 5.7 m, width 3.3 m, height 0.75 m. The distance to the three parallel slag heaps to the E is about 1.1 m. The most northerly is 6.3 m long, 4.5 m wide and 95 cm high (from the bottom edge). The middle heap is hard to define; lumps of slag lie exposed here. The distance between the two outer heaps is 5.5 m. The measurements of the S heap are length 7.0 m, width 2.5 m, height c. 0.5 m. <i>The middle of the three parallel slag heaps is defined from size and finds of slag with wood impressions as a furnace area with accumulated waste. The size thus corresponds to two production zones, one by the large oblong slag heap and one between the two smaller ones. Two sets of charcoal and ore stock-piles, identified by boring, corroborate the suggestion of two production zones.</i>	695	4	<i>Basic + Standard</i>
Id 1024419	Two parallel slag heaps aligned N-S. The E heap is 8 m long, 5 m wide and 1.3 m high. There is 6.6 m between the heaps. The W heap is 5.8 m wide, 10.3 m long and 1.3 m high. Between the heaps is a clear building 3.8 m long and 2.6 m wide. This foundation appears as a flat rise between the heaps, with a maximum height of 0.6 m. 3.8 m N of the back edge of the building is a clearance cairn painted red and blue. The E heap covers half of a square charcoal pit at the outer edge. The pit has inner diameter 6.1 m, outer d. 4 m, depth 0.7 m. C. 8 m SE is an outlier from the slag heap with slag, charcoal and furnace lining. Dimensions c. 2 × 3 m, height 0.3 m. <i>The site consists of two parallel slag heaps with slag banks that extend the heaps to the N. The interpretation of a building is based upon these, which forms an almost right-angled boundary. The furnace zone beside the slag heap to the E is clear as an oblong depression.</i>	695	2	<i>Standard</i>

Id 1024367	Tapping slag site with two parallel slag heaps, aligned NW–SE. The northernmost slag heap measures length 7.5 m, width 4.8 m, height 1.1 m. The distance between the heaps is 9 m. The southern heap measures length 6.6 m, width 4.8 m, height 0.85 m. The southernmost heap is jagged in shape and appears round. On the surface between the heaps are scattered clumps of slag. <i>/Site with two parallel slag heaps. A charcoal stockpile was identified to the SE. Tapping slag lies exposed.</i>	695	2	Standard
Id 1024695	Bloomery site of 695-type with two parallel slag heaps aligned N–S. Slag heap to the E: length 6 m, width 2.3 m, height 0.4 m. Slag heap furthest W: length 5.2 m, width 4.2 m, height 0.55 m. Distance between the slag heaps 8.4 m. <i>/Beside both slag heaps the tapping channels are clear. The channel to the S is deepest in the centre and so reveals the location of the furnace.</i>	695	2	Standard
Id 1024684	Bloomery site with two parallel slag heaps aligned NE–SW. Slag heap furthest E: length 5.7 m, width 4 m, height 0.63 m. Distance between the heaps 8 m. Slag heap furthest W: length 5 m, width 3.3 m, height 0.68 m. <i>/No clear sign of furnace zones beside the slag heaps. An ore stockpile was identified to the SW and a charcoal stockpile to NE, both by boring.</i>	695	2	Standard
Id 1024298	Bloomery site with two oblong irregular slag heaps which form a V without a point. Heap 1 is aligned N–S and has a projection to the E at the N end. Length 8 m, width 4.6 m, height 0.6 m. Between the heaps lies scattered slag. The slag does not immediately present the form of tapping slag, but the pieces are too small to be called slag lumps, possibly a furnace. Slag heap 2 to the S is oblong and measures length 8.6 m, width 5.2 m, height 0.8 m. The distance between the heaps in the middle is 6.1 m. (NW–SE). <i>/Both slag heaps are somewhat curved and so form a point. It may also be banks which make the site take this form. The slag at the point is typical pit slag and forging slag.</i>	695	2	Standard
Id 1024652	Bloomery site of the 695-type aligned E–W. Slag heap to the N: length 1.1 m, width 4.20 m, height 0.70 m. 9.50 m between the slag heaps. Slag heap to the S: length 6.5 m, width 3.5 m, height 0.5 m. <i>/Both the furnace zones are visible as slight depressions. Slag heap to the N has a slag bank to the E which extends towards the S.</i>	695	2	Standard

APPENDIX 1B *Excluded bloomery sites, not archaeologically investigated (cont.)*

Id-No.	Description from survey/excavation	Rec. type	Number of SH	Model
Id 1024625	Bloomery site of the 695-type, with two parallel slag heaps and tapping slag. Aligned NE–SW. The slag heap to the SE: length 5.3 m, width 5.1 m, height 0.6 m. Distance between the slag heaps 6.8 m. Slag heap furthest to the NW: length 7.7 m, width 4.4 m, height 0.4 m./No clear signs of furnace zones. <i>Tapping slag lies exposed in the NW slag heap.</i>	695	2	Standard
Id 1036510	Bloomery site of the 695-type with two parallel slag heaps and tapping slag. The site is aligned E–W. The slag heap furthest to the N: length 7.4 m, width 4.9 m, height 0.6 m. The slag heap furthest to the S: length 8.1 m, width 5.4 m, height 0.55 m. Distance between the slag heaps 9.4 m. The furnace area is uneven./ <i>The furnace structure is apparently defined from the slag banks to the E. A charcoal stockpile was identified to the W, and an oblong channel runs parallel with the slag heap to the S.</i>	695	2	Standard
Id 1024445	Two parallel slag heaps aligned E–W. Heap to the N: length 7.2 m, width 3.4 m, height 0.3 m. Heap to the S: length 8.1 m, width 5.7 m, height 0.7 m. A forest track/Wheel tracks run between the heaps./ <i>Deep, clear trenches alongside both the slag heaps show the position of the furnaces and tapping channels. Charcoal is visible in the wheel rut to the S.</i>	695	2	Standard
Id 1024395	Site with tapping slag. A slag heap running N–S with waste discarded on a steep slope. Length 9.4 m, width 5.4 m, height 1.1 m. The slag heap has been damaged by forestry machinery in the W, slag in the wheel tracks./ <i>The site is damaged, but tapping slag in the wheel tracks reflects the technology.</i>	695	1	Basic

Id 1024468	695	4	Standard + basic
Bloomery site of 695-type. The NE slag heap has clear projections to the NW at both ends, and has the shape of a jagged banana. The NE slag heap is 8.8 m long, 4.5 m wide and 1 m high. The SE slag heap is 7.8 m long, 6 m wide and 0.4 m high. There is a hollow edge in the middle of the slag heap, 3.6×1.1 m. A third slag heap to the N is 5 m long, 2.3 m wide and 0.3 m high. The N slag heap is at a right angle to the NE slag heap. 16 m SW of this, on sloping ground, lies a further slag heap: this slag heap is 5.8 m long, 4 m wide and 0.6 m high. <i>[The slag heap to the SE and the slag heap to the N are reinterpreted as the same slag heap, but with break in between them, probably caused by a massive tree throw. The slag heap to the SE constitutes a standard model along the N slag heap. There is a large tree throw here too. Some charcoal lies exposed to the E. The slag heap to the SW is thought to have been a separate production site.]</i>			
Id 1023147	695	2	Standard
Bloomery site with tapping slag of 695-type. Two parallel slag heaps with long axis SE–NW. The footprint of a building is well marked by various depressions between the slag heaps. Flat-bottomed slag noted. Two small heaps 2.3 to 3 m in diameter between the slag heaps (probably ore/charcoal stockpiles). <i>[The small slag heap has the form of slag banks that extend the slag heaps to the SE. The various depressions are tapping channels and furnace zones which run parallel to the slag heaps.]</i>			
Id 1023102	695	2	Standard
Bloomery site with tapping slag of 695-type. Two parallel slag heaps 6.2 m apart in the E–W direction. <i>[No clear signs of furnace zones or stockpiles of raw material.]</i>			
Id 1023107	695	2	Standard
Bloomery site of 695-type. The site consists of two parallel slag heaps where the distance between the slag heaps is 7.7 m NE–SW. The slag heap towards the SW lies partly under a tree throw with large pillars of slag which show that the slag includes tapping slag of the flat-bottomed type. The slag heap towards the NE measures 6.7×4.6 m, height 1.3 m. The furnace structure is visible between the slag heaps, but has been disturbed by tractor tracks. <i>[Two tapping cones show the technology at this site. The slag heaps have slag banks as an extension to the N, leading to an interpretation as a building. A minor depression close by the slag heap to the NE is interpreted as the furnace zone.]</i>			

APPENDIX 1B Excluded bloomery sites, not archaeologically investigated (cont.)

Id-No.	Description from survey/excavation	Rec. type	Number of SH	Model
Id 1023091	Bloomery site with tapping slag of 695-type. Two parallel slag heaps 6.8 m apart NE–SW. An ore heap lies SE of both slag heaps. The site is scarcely visible. <i>[There is no clearly visible sign of organization except for the slag heaps. Coring led to the identification of a charcoal stockpile to the NW. The ore heap is probably a roasting site where some of the ore was not used.]</i>	695	2	Standard
Id 1023086	Bloomery site with tapping slag of 695-type. Two parallel slag heaps 6.2 m apart (NE–SW). <i>[The furnace zone beside the slag heap to the NW is a clear depression.]</i>	695	2	Standard
Id 1023163	Bloomery site, probably of 695-type. A: The area has been destroyed by bulldozing. This means a lot of small pits. B: Two parallel slag heaps aligned WNE–ESE. The northern heap is in two parts. The southern heap is difficult to define. Some furnace lining at the E end of the smaller heap. Much large slag by the southern heap, small slag by the northern. Damaged by building preparation. <i>[Damaged site. Ore exposed to the SE. Tapping slag, slag with wood impressions and pit slag imply the usual technology.]</i>	695	2	Standard
Id 1023736	The 695-type with two slag heaps. Distance between the slag heaps 6.9 m NW–SE. The NE slag heap measures $9.7 \times 5.3 \times 1.3$ m. The SW slag heap measures $8.9 \times 5.0 \times 1.3$ m. The furnace structure is clearly marked, and the slag heaps have extensions containing slag: the NE one at both ends and the SE one at the SE end. <i>[The slag banks are the basis for interpretation as a furnace shed. Tapping channels are visible beside both slag heaps. Ore was identified by boring in the NW.]</i>	695	2	Standard

Id 1023856	Bloomery site with two parallel slag heaps aligned ssw-nne. Distance between the heaps is 6.8 m. The slag heap to the W measures 7.0 m × 3.7 m × 0.6 m. The slag heap to the E measures 6.1 m × 4.8 m × 1.0 m. Between the slag heaps lies a possible building aligned ssw-nne. The internal dimension N-s is 4.8 × 2.9 m. A terrace/floor of earth, 0.4 m high, seems to have been constructed inside the furnace structure and is probably secondary to the 695-site. Ore stockpile identified by test probe inside the structure. An ironmaking site of the 300-type lies 2 m NE of the E slag heap of the 695-type. The heap is roughly round, some slag has been thrown out down a slight slope. Dimensions: 3.5 m × 3.5 m × 0.6 m./The suggested structure is probably based on a surface bounded by two tapping channels. The production zone will have lain here with an ore stockpile to the N and charcoal stockpile to the S. The smaller slag heap lies by the slight slope to the E and had its own production zone to the NW, even though this has not been identified.	695 + 300	3	Basic + Standard
Id 1023202	Bloomery site of 695-type. Two oblong/circular slag heaps aligned ene-wsw. 1 m W of the E slag heap: a small, amorphous pit with a low hint of a bank around it. 2 m S of the pit can be seen an E-W trench 6-7 m long which may be a drain on the outer side of a possible furnace structure. Apparently an ore stockpile in a 2 m long and 1 m wide heap between the pit and the W slag heap./The pit recorded is the furnace zones and the trench is the end of the tapping channel. The channel is less deep close to the pit, probably because of accumulated waste lying here. The ore stockpile can be seen as a small mound to the N. A charcoal stockpile was identified to the S.	695	2	Standard
Id 1036846	Bloomery site with one slag heap of the 695-type. A steep slag heap of oblong form. Length 6.4 m, width 5 m, height 1 m./A minor depression beside the E side of the slag heap shows the location of the furnace and also where the production zone was.	695	1	Standard

APPENDIX 1B *Excluded bloomery sites, not archaeologically investigated (cont.)*

Id-No.	Description from survey/excavation	Rec. type	Number of SH	Model
Id 1023023	Bloomery site of 695-type with tapping slag. Two parallel slag heaps 10.9 m apart N-s. The slag heap to the S measures 5.6 m E-W, 4.6 m N-S, height 0.9 m. The slag heap to the N measures 5.0 m E-W, 2.6 m N-S, height 0.4 m. <i>(Clear tapping channels which are deepest at the centre show the location of the furnaces.</i>	695	2	Standard
Id 1023075	Bloomery site with tapping slag. May be of the 695-type (one phase). But a different type cannot be ruled out. The slag heap lies on a brow above a bog to the N and W. The slag heap measures 4.0 m E-W, 4.4 m N-S, height 0.4 m. <i>(In addition to the nearly round slag heap, an inconspicuous heap was identified 5.5 m to the E. This has a height of 0.2 m and lies slightly down in a hollow. No clear furnace zones can be defined.</i>	695	2	Standard
Id 1023760	An oblong slag heap of the 695-type aligned E-W, measuring 3.7 × 5.1 × 0.7 m. The furnace structure is 6.0 m long and bounded by an earth bank to the N. The earth bank and slag heap are bounded by a long wall at the back edge and create a U-shaped structure which apparently lies over an earlier Bloomery site with slag discarded out over the slope. The waste slag is marked as a clear terrace edge and measures 8.9 m in width, 5.4 m in length and is 20 cm thick. It ends beside a swampy area. The waste slag appears to consist of tapping slag. <i>(It was not possible to make out any structure as the surveys describe it. The discarded slag together with the slag heap constitute a normal pattern with a production zone between them, although to the N the slag is deposited on a slope. The earth bank consists of disturbed material and is probably the remains of a major tree throw.</i>	695	2	Standard

APPENDIX IIA 14C-datings and dendrochronological datings from the Gräffell area

Site No.	Dating—14C		Dating—dendro			Context
	Lab ref.	BP-age ranges ±	Calibrated	Species	Felling date	
Jfp.1	T-16729	820	AD1165–1280	Picea		Profile trench I, top
Jfp.1	T-16730	835	AD1065–1285	Picea		Profile trench I, bottom
Jfp.1	T-16731	225	Y. enn AD1650	Picea		Roasting place 2
Jfp.1	T-16732	905	AD1035–1220	Pinus	A. summer AD1167–1261 94 + 2 years	Furnace 2, staves in lining AD1264
Jfp.1	T-16733	845	AD1165–1265	Picea		Furnace 1, staves in lining
Jfp.1	T-16734	870	AD1045–1255	Picea		Fire place
Jfp.1	TUa-4442	955	AD1025–1160	Picea		Slag heap SH 1
Jfp.1-2	T-16893	885	AD1040–1230	Picea	Relatively dated	
Jfp.1-4	T-18464	840	AD1165–1275	Picea	109 + 2 years	
Jfp.2	T-16735	855	AD1065–1260	Pinus		Slag heap SH 1
Jfp.2	T-16736	955	AD1015–1180	Pinus		Slag heap SH 2
Jfp.2	T-16737	960	AD1015–1165	Pinus		Charcoal stockpile
Jfp.2	T-16738	770	AD1220–1295	Pinus		Roasting place
Jfp.2	T-16739	825	AD1175–1280	Picea		Ore stockpile
Jfp.2	T-16740	805	AD1170–1285	Pinus	48 years +. To few for dating	Furnace 1, staves in lining

APPENDIX IIA 14C-datings and dendrochronological datings from the Gräffell area (cont.)

Site No.	Dating— ¹⁴ C		Dating— <i>dendro</i>			Context		
	Lab ref.	BP-age	ranges ±	Calibrated	Species			
Jfp.2	T-16741	770	45	AD1230–1290	Pinus	AD1191–1297 106 + 5 years	A. summer AD1302 Relatively dated	Furnace 2, staves in lining
Jfp.2-1	T-16894	800	50	AD1215–1285	Picea/ pinus		59 year, picea.	Top
Jfp.2-1	T-16895	790	65	AD1215–1290	Pinus			Base
Jfp.2-2	T-16896	810	45	AD1215–1280	Pinus			Phase 1
Jfp.2-3	T-16897	840	75	AD1070–1280	Pinus			Phase 2
Jfp.2-3	T-16898	745	65	AD1240–1300	Picea			Charcoal stockpile
Jfp.2-4	T-16899	865	45	AD1160–1230	Pinus			Slag heap SH 2
Jfp.3	T-16746	770	45	AD1230–1295	Pinus			Furnace 2, staves in lining
Jfp.3	T-16747	875	75	AD1040–1255	Pinus			Furnace 1, staves in lining
Jfp.3	T-16748	865	75	AD1045–1270	Picea			Furnace 1, staves in lining
Jfp.3	T-16749	710	75	AD1275–1385	Picea/ pinus			Fire place
Jfp.3	TUa-4444	865	35	AD1165–1225	Pinus			Slag heap SH 1
Jfp.3	TUa-4445	975	35	AD1020–1255	Pinus			Furnace 3, staves in lining
Jfp.3	T-17660	1070	65	AD895–1020	Pinus			Furnace 4, staves in lining
Jfp.3	T-17661	1025	40	AD995–1030	Pinus		>30 years. To few for dating.	

Jfp.3-1	T-16900	900	75	AD1030–1225	Picea
Jfp.3-4	T-16901	795	40	AD1225–1280	Pinus
Jfp.3-7	T-16902	815	55	AD1190–1280	Pinus
Jfp.3-6	T-16903	985	65	AD1005–1160	Pinus
Jfp.3-9	T-16904	760	75	AD1225–1295	Picea
Jfp.3-8	T-16905	750	50	AD1250–1295	Pinus
Jfp.3-5	T-16906	765	75	AD1220–1295	Picea
Jfp.3-12	T-16907	1180	60	AD780–965	Pinus
Jfp.3-14	T-16909	850	45	AD1165–1250	Pinus
Jfp.3-11	T-16910	860	40	AD1165–1235	Picea
Jfp.3-10	T-16911	890	75	AD1035–1245	Pinus
Jfp.3-13	T-18334	840	75	AD1065–1280	Pinus
Jfp.4	T-16742	1075	75	AD890–1025	Picea
Jfp.4	T-16743	835	75	AD1160–1280	Picea
Jfp.4	T-16744	920	75	AD1025–1220	Pinus
Jfp.4	T-16745	975	65	AD1010–1165	Picea
Jfp.4	T-18467	500	60	AD1405–1445	Pinus
Jfp.4-1	T-16908	880	50	AD1050–1225	Picea
Jfp.4-2	T-15831	850	75	AD1060–1275	Picea
Jfp.4-2	T-15832	790	60	AD1250–1285	Picea
Jfp.5	T-16750	835	75	AD1160–1280	Picea/ pinus
Jfp.5	T-16751	780	75	AD1215–1290	Pinus
Jfp.5	T-16752	915	75	AD1025–1220	Pinus

APPENDIX 11A 14C-datings and dendrochronological datings from the Gräffell area (cont.)

Site No.	Dating—14C		Dating—dendro		Context
	Lab. ref.	BP-age ranges ±	Calibrated	Species	Felling date
Jfp.5	T-16753	865	AD1045–1265	Pinus	Furnace 2, staves in lining
Jfp.5	T-16754	935	AD1020–1215	Picea	Furnace 5, staves in lining
Jfp.5	T-16755	810	AD1170–1285	Pinus	Relatively dated
Jfp.5	T-16756	765	AD1220–1295	Pinus	AD1126–1243 117 + 6 years A. summer AD1249
Jfp.5	T-16757	1000	AD985–1160	Pinus	AD1113–1201 88 + 35 years A. summer AD1236
Jfp.5	TUa-4446	815	AD1215–1275	Picea	Slag heap SH 4, top
Jfp.5	TUa-4447	960	AD1025–1160	Pinus	Fire place
Jfp.5	TUa-4448	760	AD1255–1290	Pinus	Slag heap SH 4, base
Jfp.5	TUa-4449	915	AD1040–1180	Pinus	Slag heap SH 1, base
Jfp.5-4	T-16887	700	AD1275–1390	Picea	Slag heapg SH 1, top
Jfp.5-4	T-16888	835	AD1160–1280	Picea	Phase 1
Jfp.5-4	T-16889	760	AD1225–1295	Picea	Phase 2
Jfp.5-4	T-16890	745	AD1235–1300	Picea	Phase 3
Jfp.5-5	T-16891	880	AD1040–1235	Picea	Phase 4
Jfp.5-1	T-16892	860	AD1060–1260	Pinus	69 years. To few for dating.
Jfp.6	T-16758	1130	AD880–985	Picea	
Jfp.6	T-16759	710	AD1270–1380	Pinus	
Jfp.6	T-16760	845	AD1060–1280	Pinus	
					Charcoal stockpile 1
					Slag heap SH 1
					Slag heap SH 2

Jfp.6	T-16761	830	75	AD1165-1280	Pinus	>30 years. To few for dating.	Furnace 1, staves in lining
Jfp.6	T-16762	820	75	AD1165-1285	Picea	44 + 1 years	Furnace 2, staves in lining
Jfp.6	T-16767	845	65	AD1165-1275	Picea	Relatively dated	Charcoal stockpile 2
Jfp.6	TUa-4450	1010	35	AD1005-1030	Pinus		Fire place
Jfp.6	TUa-4451	745	40	AD1260-1295	Picea		Ore stockpile/roasting place
Jfp.6-11	T-16874	840	50	AD1165-1270	Picea	125 + 10 years	
Jfp.6-1	T-16875	845	65	AD1165-1275	Picea	Relatively dated	
Jfp.6-12	T-16876	855	75	AD1050-1275	Picea		
Jfp.6-2	T-16877	845	60	AD1165-1275	Pinus	AD1128-1207 79 + 1 years	A. summer AD1208
Jfp.6-13	T-16878	945	65	AD1020-1175	Pinus	Abnormal variation in tree rings	
Jfp.6-14	T-16879	800	65	AD1205-1285	Picea	78 years	Relatively dated
Jfp.6-5	T-16880	865	50	AD1065-1240	Pinus		
Jfp.6-3	T-16881	830	75	AD1165-1280	Picea/ pinus		
Jfp.6-6	T-16882	840	85	AD1055-1220	Picea		
Jfp.6-15	T-16883	915	75	AD1025-1220	Picea/ pinus		
Jfp.6-8	T-16884	860	40	AD1165-1235	Picea		
Jfp.6-9	T-16885	1040	60	AD970-1030	Pinus		
Jfp.6-10	T-16886	845	60	AD1160-1270	Picea		
Jfp.7	T-16726	825	45	AD1185-1275	Picea		Furnace, staves in lining
Jfp.7	T-16727	850	65	AD1160-1270	Picea		Slag waste
Jfp.7	T-16728	760	75	AD1225-1295	Picea		Charcoal stockpile
Jfp.7-1	T-16912	900	65	AD1035-1225	Pinus		

APPENDIX IIA 14C-datings and dendrochronological datings from the Gräffell area (cont.)

Site No.	Dating—14C			Dating—dendro			Context
	Lab. ref.	BP-age	ranges ±	Calibrated	Species	Tree rings	Felling date
Jfp.7-2	T-17431	880	75	AD1040–1245	Picea		Amundsen 2007
Jfp.8	T-17311	810	75	AD1170–1285	Pinus		Slag heap SH 1, base
Jfp.8	T-17314	885	75	AD1035–1245	Pinus		Slag heap SH 3, base
Jfp.8	T-17317	900	50	AD1040–1215	Pinus		Processing zone
Jfp.8	T-17318	845	50	AD1165–1260	Pinus		Furnace 1, staves in lining
Jfp.8	T-17319	715	80	AD1260–1385	Pinus		Furnace 2, staves in lining
Jfp.8	T-17321	945	80	AD1015–1210	Pinus		Furnace 3, staves in lining
Jfp.8	TUa-4914	980	40	AD1015–1155	Pinus		Slag heap SH 2, base
Jfp.8-1	T-17308	985	75	AD995–1165	Pinus		
Jfp.8-6	T-17309	945	60	AD1020–1170	Pinus		
Jfp.8-4	T-17310	990	55	AD1010–1155	Picea		
Jfp.8-7	T-17313	820	75	AD1165–1285	Picea		
Jfp.8-2	T-17315	785	65	AD1220–1290	Picea		
Jfp.8-3	T-17316	925	40	AD1035–1175	Picea		
Jfp.8-5	T-17320	770	65	AD1225–1295	Picea		
Jfp.9	T-17288	920	60	AD1025–1215	Pinus		Slag heap SH 1
Jfp.9	T-17289	975	60	AD1010–1160	Pinus		Roasting place 3a
Jfp.9	T-17290	965	65	AD1015–1165	Pinus		Furnace 3, staves in lining

No match to other samples

Jfp.9	T-17291	835	75	AD1160-1280	Pinus	Furnace 2, staves in lining Charcoal stockpile 3 Furnace 4, staves in lining Furnace 1, staves in lining Fire place
Jfp.9	T-17292	880	65	AD1045-1235	Pinus	
Jfp.9	T-17293	765	75	AD1220-1295	Picea	
Jfp.9	T-17294	1015	80	AD975-1155	Pinus	
Jfp.9	TUa-5315	845	35	AD1175-1245	Burned bones	
Jfp.9-12	T-17287	790	70	AD1215-1290	Pinus	Charcoal stockpile Furnace, staves in lining Cooking pit Charcoal burning phase Occupation phase
Jfp.10	T-17297	815	80	AD1165-1285	Pinus	
Jfp.10	T-17302	1060	50	AD970-1020	Pinus	
Jfp.10	TUa-4913	2275	35	BC390-255	Pinus	
Jfp.10-6	T-17296	1040	60	AD970-1030	Picea	
Jfp.10-6	TUa4912	930	35	AD1035-1165	Picea	48 year. To few for dating
Jfp.10-2	T-17295	860	65	AD1060-1260	Picea	
Jfp.10-5	T-17298	865	50	AD1160-1235	Picea	
Jfp.10-1	T-17299	830	75	AD1165-1280	Pinus	
Jfp.10-3	T-17303	895	40	AD1050-1215	Picea	
Jfp.10-4	T-17304	865	70	AD1045-1255	Picea	
Jfp.11	T-17325	915	75	AD1025-1225	Pinus	
Jfp.11	T-17323	875	80	AD1040-1260	Pinus	
Jfp.11	T-17326	810	80	AD1165-1285	Pinus	
Jfp.11-1	T-17322	905	75	AD1030-1230	Pinus	
Jfp.11-6	T-17324	895	75	AD1030-1230	Pinus	Furnace 1, staves in lining Roasting place Furnace 2, staves in lining
Jfp.12	T-17645	985	75	AD995-1160	Pinus	
Jfp.12	T-17646	865	65	AD1055-1255	Pinus	
Jfp.12	T-17647	1135	50	AD885-980	Pinus	
						Unemptied charcoal pit Slag heap sH 2, bottom Slag waste Slag heap sH 1

APPENDIX IIA 14C-datings and dendrochronological datings from the Gräffell area (cont.)

Site No.	Dating—14C		Dating—dendro			Context
	Lab. ref.	BP-age	ranges ±	Calibrated	Species	Felling date
Jfp.12	T-17648	870	50	AD1065–1230	Pinus	Furnace 1, staves in lining
Jfp.12	T-17649	890	65	AD1040–1225	Pinus	Furnace 4, staves in lining
Jfp.12	T-17650	925	75	AD1020–1215	Pinus	Furnace 2, staves in lining
Jfp.12	T-17651	990	75	AD995–1160	Pinus	Fire place 2
Jfp.12	T-17652	885	50	AD1050–1225	Pinus	Furnace 6, sjaktFurnace
Jfp.12	T-17653	925	65	AD1025–1215	Pinus	Charcoal stockpile 5
Jfp.12	T-17654	1000	75	AD985–1160	Pinus	Furnace 5, sjaktFurnace
Jfp.12	T-17655	945	65	AD1020–1185	Pinus	Furnace 3, staves in lining
Jfp.12	TUa-5317	1275	30	AD685–780	Pinus	Fire place 1
Jfp.12	TUa-5316	815	35	AD1215–1275	Burned bones	Fire place 2
Jfp.12-7	T-17644	1035	75	AD900–1035	Pinus	Abnormal variation in tree rings
Jfp.13	T-17631	1135	65	AD875–990	Pinus	
Jfp.13	T-17632	720	75	AD1255–1375	Pinus	Fire place
Jfp.13	T-17633	800	45	AD1220–1280	Pinus	Furnace 1, staves in lining
Jfp.13	T-17634	890	45	AD1050–1220	Picea	Furnace 2, staves in lining
Jfp.13	TUa-5307	975	35	AD1020–1155	Burned bones	Slag heap SH 1
Jfp.14	T-17599	905	40	AD1040–1215	Pinus	Fire place
Jfp.14	T-17600	895	40	AD1045–1215	Pinus	Slag heap SH 2
Jfp.14	T-17601	870	40	AD1160–1225	Pinus	Fire place 3
						Roasting place 1

Jfp.14	T-17602	920	50	AD1030–1190	Pinus	Roasting place 2
Jfp.14	T-17603	980	65	AD1010–1160	Pinus	Charcoal stockpile 2
Jfp.14	T-17604	930	65	AD1025–1205	Pinus	Fire place 1
Jfp.14	T-17607	830	65	AD1165–1280	Pinus	Tuft
Jfp.14	T-17609	965	50	AD1020–1160	Pinus	Furnace 3, staves in lining
Jfp.14	T-17610	880	80	AD1040–1255	Pinus	Furnace 2, staves in lining
				AD1059–1240 181 + 20 years	Eter AD1260	
Jfp.14	T-17612	910	75	AD1025–1225	Pinus	Furnace 1, staves in lining
Jfp.14	TUa-5295	900	40	AD1045–1215	Pinus	Fire place 2
Jfp.14-17	T-17598	825	75	AD1165–1280	Pinus	Charcoal burning phase
Jfp.14-17	T-17611	820	75	AD1165–1285	Pinus	Occupation phase
Jfp.14-16	T-17605	1025	75	AD970–1150	Pinus	
Jfp.14-18	T-17606	785	75	AD1215–1290	Pinus	
Jfp.14-1	T-17608	940	50	AD1025–1165	Pinus	
Jfp.15	T-17305	820	70	AD1170–1280	Picea	Charcoal stockpile
Jfp.15	T-17306	725	70	AD1255–1370	Picea	Furnace 1, staves in lining
Jfp.15	T-17307	820	65	AD1170–1280	Picea	Furnace 2, staves in lining
Jfp.16	TUa-5308	1185	25	AD820–890	Pinus	Charcoal stockpile, bottom
Jfp.16	TUa-5309	1160	30	AD880–955	Pinus	Slag heap, base
Jfp.16	T-17638	865	65	AD1050–1255	Pinus	Furnace, staves in lining
Jfp.16	T-18465	945	60	AD1020–1170	Pinus	Log below charcoal stockpile
Jfp.16-2	T-17635	835	40	AD1175–1260	Pinus	
Jfp.16-1	T-17636	820	75	AD1165–1280	Pinus	
				>30 years, To few for dating		

APPENDIX IIA 14C-datings and dendrochronological datings from the Gråffell area (cont.)

Site No.	Dating— ¹⁴ C		Dating—dendro			Context	
	Lab. ref.	BP-age	ranges ±	Calibrated	Species		Tree rings
Jfp.16-1	T-17637	860	75	AD1050–1275	Pinus		Base
Jfp.16-3	T-15828	795	45	AD1220–1280	Pinus		Base (Bockman & Bergstøl 2001)
Jfp.16-3	T-15830	890	45	AD1050–1220	Betula/pinus		Embankment (Bockman & Bergstøl 2001)
Jfp.17	T-17658	785	75	AD1215–1290	Pinus		Charcoal stockpile
Jfp.17	T-17659	845	75	AD1060–1280	Pinus	AD1187–1266 79 years +	Furnace, staves in lining
Jfp.17-1	T-17656	870	55	AD1055–1245	Picea		
Jfp.18	TUa-5311	1700	25	AD270–405	Pinus		Roasting fire 1
Jfp.18	T-17642	1460	65	AD550–655	Pinus		Charcoal pit, base
Jfp.18	T-17641	1345	75	AD645–770	Pinus		Furnace zone
Jfp.18	TUa-5483	500	35	AD1410–1440	Pinus		Roasting fire 4
Jfp.18	T-18466	1470	50	AD550–650	Pinus		Charcoal stockpile, top
Jfp.19	T-17625	775	50	AD1225–1290	Pinus		Furnace 2, staves in lining
Jfp.19	T-17626	945	75	AD1015–1205	Pinus		Furnace 1, staves in lining
Jfp.19	TUa-5298	1205	40	AD780–890	Pinus		Slag heap sH 1, bottom
Jfp.19	TUa-5299	695	40	AD1285–1305	Pinus		Slag heap sH 2, bottom
Jfp.19	TUa-5301	945	40	AD1025–1165	Pinus		Fire place 1

Jfp.19	TUa-5302	1640	40	AD395-440	Pinus	Fire place 2
Jfp.19-4	T-17618	875	40	AD1065-1225	Picea	
Jfp.19-4	T-17619	850	60	AD1165-1260	Picea	Side pit
Jfp.19-6	T-17620	855	65	AD1065-1265	Picea	
Jfp.19-2	T-17621	750	50	AD1250-1295	Picea	
Jfp.19-7	T-17622	865	65	AD1050-1255	Picea	
Jfp.19-3	T-17623	1200	50	AD780-890	Pinus	Side pit
Jfp.19-3	T-17624	880	75	AD-1040-1250	Picea	
Jfp.19-5	TUa-5300	785	40	AD1225-1285	Picea	Roasting place
Jfp.20	T-17627	915	80	AD1025-1225	Pinus	Furnace 1, staves in lining
Jfp.20	T-17628	735	75	AD1240-1305	Pinus	Fire place 2
Jfp.20	T-17629	980	75	AD1000-1165	Pinus	Furnace 2, staves in lining
Jfp.20	T-17630	930	40	AD1030-1165	Pinus	Processing zone
Jfp.20	TUa-5303	950	40	AD1025-1160	Pinus	Fire place 1
Jfp.20	TUa-5304	890	40	AD1050-1220	Pinus	Fire place 1
Jfp.20	TUa-5305	955	35	AD1025-1160	Burned bones	Tuft
Jfp.20	TUa-5306	840	40	AD1175-1255	Pinus	Charcoal stockpile
Jfp.21	T-17613	755	80	AD1225-1300	Pinus	Charcoal stockpile
Jfp.22	T-17617	880	50	AD1050-1225	Picea	Charcoal stockpile
Jfp.23	T-17942	980	75	AD1000-1165	Picea	Furnace 3, staves in lining
Jfp.23	T-17943	825	75	AD1165-1280	Picea	Furnace 1, staves in lining
Jfp.23	T-17944	860	80	AD1050-1275	Picea	Furnace 2, staves in lining
Jfp.23	T-17945	690	70	AD1280-1390	Picea	Slag heap sH 1, bottom
Jfp.23	T-17994	905	75	AD1025-1225	Picea	

APPENDIX IIA 14C-datings and dendrochronological datings from the Gräffell area (cont.)

Site No.	Dating—14C		Dating—dendro			Context
	Lab. ref.	BP-age	ranges ±	Calibrated	Species	Felling date
Jfp.23	TUa-5803	1070	35	AD970-1015	Burned bones	Fire place
Jfp.23	TUa-5549	940	40	AD1030-1165	Pinus	Fire place
Jfp.23-1	T-17615	855	50	AD1165-1255	Picea	
Jfp.23-7	T-17992	810	75	AD1170-1285	Picea	
Jfp.23-9	T-17993	920	75	AD1025-1220	Picea	
Jfp.23-6	T-17995	955	75	AD1015-1180	Picea	
Jfp.23-5	T-17996	820	45	AD1200-1275	Picea	
Jfp.23-11	T-17997	765	65	AD1225-1295	Picea	
Jfp.23-3	T-17998	935	75	AD1020-1215	Picea	
Jfp.23-4	T-17999	850	75	AD1055-1275	Picea	
Jfp.23-4	T-18000	935	50	AD1025-1170	Picea	Side pit
Jfp.23-2	T-17975	970	65	AD1010-1165	Picea	
Jfp.23-8	T-17991	775	75	AD1215-1295	Picea	
Jfp.23-10	T-18001	770	65	AD1220-1290	Picea	
Jfp.24	T-17616	945	65	AD1020-1180	Picea	Charcoal stockpile
Jfp.25	TUa-5297	780	40	AD1230-1285	Pinus	Charcoal stockpile
Jfp.26	T-17614	835	75	AD1160-1280	Pinus	Charcoal stockpile
Jfp.27	TUa-5296	940	40	AD1025-1165	Picea	Charcoal stockpile
Jfp.28	T-17946	940	75	AD1020-1215	Pinus	Charcoal stockpile

Jfp.28	T-18194	870	60	AD1050-1245	Pinus		Fire place
Jfp.28	T-17949	840	80	AD1060-1280	Pinus	AD1040-1174 134 years +	Furnace 1, staves in lining
Jfp.28	T-18193	790	65	AD1215-1290	Pinus		Furnace 2, staves in lining
Jfp.28	TUa-5805	1055	35	AD980-1015	Burned bones		Fire place
Jfp.28-11	T-17947	1095	75	AD885-1015	Pinus		Side pit
Jfp.28-11	T-17948	950	75	AD1015-1280	Pinus	AD1023-1148 125 years +	
Jfp.29	T-17935	65	55	Y. enn AD1700	Pinus		Burned log
Jfp.29	T-17936	1115	70	AD880-1005	Pinus		Charcoal stockpile 1
Jfp.29	T-17937	1030	65	AD975-1035	Pinus		Charcoal stockpile 2
Jfp.29	T-17938	815	65	AD1175-1285	Pinus		Furnace 3, staves in lining
Jfp.29	T-17939	900	75	AD1030-1230	Pinus		Furnace 4, staves in lining
Jfp.29	T-17940	1000	65	AD995-1155	Pinus		Furnace 1, staves in lining
Jfp.29	T-17941	1000	65	AD990-1155	Pinus		Furnace 2, staves in lining
Jfp.29-2	T-17934	985	75	AD995-1165	Pinus		
Jfp.29-9	T-17980	955	45	AD1025-1160	Pinus		
Jfp.29-5	T-17981	1060	65	AD895-1035	Pinus		
Jfp.29-1	T-17982	1050	75	AD895-1030	Pinus		
Jfp.29-6	T-17983	840	65	AD1165-1275	Pinus		
Jfp.29-3	T-17984	920	40	AD1030-1185	Pinus		Tilted log
Jfp.29-3	T-17985	750	75	AD1225-1300	Pinus		log layer 2
Jfp.29-3	T-17986	895	65	AD1035-1225	Pinus		Sill beam
Jfp.29-4	T-17987	1055	80	AD895-1030	Pinus		
Jfp.29-7	T-17988	845	65	AD1160-1275	Pinus		
Jfp.29-8	T-17989	885	75	AD1035-1250	Pinus		

APPENDIX IIA 14C-datings and dendrochronological datings from the Gräffell area (cont.)

Site No.	Dating—14C		Dating—dendro			Context
	Lab ref.	BP-age	ranges ±	Calibrated	Species	Felling date
Jfp.29-8	T-17990	1010	65	AD985-1150	Pinus	Side pit
Jfp.30	T-18177	725	50	AD1275-1300	Pinus	Roasting place 14
Jfp.30	T-18178	150	60	Y. enn AD1670	Pinus	Roasting place 4
Jfp.30	T-18179	850	70	AD1060-1275	Pinus	Slag heap SH 2
Jfp.30	TUa-5802	955	40	AD1025-1160	Salix/populus	Slag heap SH 2, bottom
Jfp.30	T-18180	910	80	AD1025-1225	Pinus	Slag heap SH 1
Jfp.30	T-18181	1005	65	AD990-1155	Pinus	Slag heap SH 4
Jfp.30	T-18182	895	75	AD1030-1230	Pinus	Charcoal stockpile 2
Jfp.30	T-18183	1085	75	AD890-1020	Pinus	Charcoal stockpile 1
Jfp.30	T-18184	1185	65	AD775-965	Pinus	Furnace 4, staves in lining Furnace 1, staves in lining, phase 2 Furnace 3, staves in lining Furnace 1, staves in lining, phase 1
Jfp.30	T-18185	800	60	AD1215-1285	Pinus	
Jfp.30	T-18186	825	70	AD1165-1280	Pinus	
Jfp.30	T-18187	1085	65	AD890-1015	Pinus	
Jfp.30	T-18188	1050	75	AD895-1030	Pinus	
Jfp.30-2	T-18190	1020	70	AD975-1040	Pinus	
Jfp.30-1	T-18189	985	75	AD995-1165	Pinus	Abnormal variation in tree rings

Jfp.30-4	T-18192	745	60	AD1215-1290	Pinus	Cell structure deformed AD1043-1164 121 years + Etter AD1164	Slag heap SH 2
Jfp.30-3	T-18191	700	65	AD1280-1380	Pinus		Slag heap SH 1
Jfp.31	T-18195	1340	75	AD650-775	Pinus		Furnace 1, staves in lining
Jfp.31	T-18196	1055	65	AD895-1025	Pinus		Furnace 2, staves in lining
Jfp.31	T-18197	945	75	AD1015-1210	Pinus		Fire place
Jfp.31	T-18198	780	60	AD1220-1295	Pinus		Fire place
Jfp.31	T-18202	770	75	AD1220-1295	burned bones		
Jfp.31	TUa-5806	755	35	AD1260-1290	Pinus		
Jfp.31-8	T-18199	1115	65	AD885-1005	Pinus		
Jfp.31-10	T-18200	800	75	AD1175-1285	Pinus		
Jfp.31-9	T-18201	930	75	AD1020-1215	Pinus		
Jfp.31-11	T-18203	1055	50	AD970-1020	Pinus		
Jfp.31-2	T-18204	1005	65	AD990-1155	Pinus		
Jfp.31-1	T-18205	1000	75	AD985-1155	Pinus		
Jfp.31-7	T-18206	835	65	AD1165-1275	Pinus		
Jfp.31-4	T-18207	970	75	AD1005-1165	Pinus		
Jfp.31-6	T-18208	950	65	AD1020-1170	Pinus		
Jfp.31-5	T-18209	1095	45	AD890-1005	Pinus		
Jfp.32	T-18002	980	75	AD1000-1165	Pinus	Furnace 1, staves in lining	
Jfp.32	T-18003	915	65	AD1030-1220	Pinus	Furnace 2, staves in lining	
Jfp.32	TUa-5574	930	35	AD1030-1165	Pinus	Fire place	
Jfp.32	TUa-5804	1045	35	AD980-1020	Br. bein	Fire place	
Jfp.32	T-18331	880	65	AD1045-1235	Pinus	Charcoal stockpile 2	
Jfp.32	T-18332	950	65	AD1020-1170	Pinus	Charcoal stockpile 1	

APPENDIX IIA 14C-datings and dendrochronological datings from the Gräffell area (cont.)

Site No.	Dating—14C		Dating—dendro			Context
	Lab ref.	BP-age	ranges ±	Calibrated	Species	Felling date
Jfp.33	T-18212	1375	75	AD630-695	Pinus	Slag heap sH 2
Jfp.33	T-18214	915	75	AD1025-1220	Pinus	Furnace 1, staves in lining
Jfp.33	T-18210	890	65	AD1035-1230	Picea	Charcoal stockpile
Jfp.33	T-18211	890	95	AD1025-1255	Picea/ pinus	Slag heap sH 1
Jfp.33	T-18213	755	75	AD1225-1300	Pinus	Furnace 2, staves in lining
Jfp.34	T-18005	695	75	AD1280-1390	Pinus	Furnace 2, staves in lining
Jfp.34	T-18006	835	65	AD1165-1280	Pinus	Furnace 3, staves in lining
Jfp.34	T-18007	845	75	AD1060-1280	Pinus	Furnace 4, staves in lining
Jfp.35	T-18008	820	70	AD1165-1280	Picea	Charcoal stockpile
Jfp.36	T-18014	840	75	AD1065-1280	Picea	Charcoal stockpile
Jfp.37	T-18013	1020	55	AD985-1035	Pinus	Charcoal stockpile
Jfp.37-1	T-17976	575	75	AD1305-1430	Pinus	Charcoal stockpile
Jfp.37-2	T-17933	810	75	AD1170-1285	Pinus	Charcoal stockpile
Jfp.37-3	T-17977	955	75	AD1015-1180	Pinus	Charcoal stockpile
Jfp.37-4	T-17978	855	75	AD1055-1275	Pinus	
Jfp.37-5	T-17979	930	75	AD1020-1215	Pinus	
Jfp.38	T-18333	660	75	AD1285-1400	Picea	Charcoal stockpile
Jfp.39	T-15814	900	50	AD1040-1215	Pinus	Fire place (K14)

Jfp.39	T-15815	815	70	AD1170-1285	Picea	Slag heap SH ₂ (K ₂), base
Jfp.39	T-15816	920	75	AD1025-1220	Picea	Slag heap SH ₁ (K ₁), base
Jfp.39	T-15817	920	75	AD1025-1220	Pinus	Slag heap SH ₁ (K ₁), top
Jfp.39	T-15818	750	70	AD1225-1300	Pinus	Charcoal stockpile (K6)
Jfp.39	T-15819	995	55	AD1005-1155	Picea	Slag tapping furnace (K15)
Jfp.39	T-15820	865	75	AD1045-1265	Pinus	Isolation pit (K30)
Jfp.39	T-15821	920	45	AD1035-1180	Pinus	Slag tapping furnace (K32)
Jfp.39	T-15822	740	60	AD1250-1300	Pinus	Isolation pit (K29)
Jfp.39	T-15823	860	40	AD1165-1235	Pinus	Slag tapping furnace (K31)
Jfp.39	T-15824	770	65	AD1225-1290	Pinus	Isolation pit ((K25)
Jfp.39	T-15825	765	40	AD1240-1290	Pinus	Isolation pit ((K35)
Jfp.39	TUa-3592	1000	45	AD1005-1040	Pinus	Slag heap SH ₂ (K ₂), top
Jfp.39-8	T-15826	935	50	AD1025-1170	Pinus	
<i>Enkeltliggende kullgrøper</i>						
Kg.2	T-16725	1100	75	AD885-1015	Pinus	
Kg.10	T-18010	990	75	AD995-1160	Pinus	
Kg.11	T-18011	870	40	AD1160-1225	Picea	
Kg.12	T-18012	740	55	AD1255-1295	Pinus	
<i>Enkeltliggende Roasting places</i>						
Rp.1	TUa-4443	2395	35	BC485-400	Pinus	
Rp.2	T-17657	855	50	AD1160-1250	Pinus	
Rp.3	T-17639	850	65	AD1070-1265	Pinus	
Rp.4	TUa-5310	965	25	AD1025-1155	Pinus	
Rp.5	TUa-5312	845	30	AD1175-1240	Picea	

Fire 1

APPENDIX IIA 14C-datings and dendrochronological datings from the Gråffell area (cont.)

Site No.	Dating—14C		Dating—dendro			Context
	Lab. ref.	BP-age	ranges ±	Calibrated	Species	Felling date
Rp.5	TUa-5313	1040	30	AD990–1020	Picea	Fire 2
Rp.5	T-17640	855	90	AD1045–1280	Picea	Fire 4
Rp.6	TUa-5314	1165	30	AD875–945	Picea	
Rp.7	TUa-5575	915	40	AD1040–1190	Picea	Fire 6
Rp.15	T-18015	885	95	AD1030–1265	Picea	
Rp.16	T-18016	1350	95	AD630–780	Pinus	
Rp.17	T-18017	1340	60	AD650–770	Pinus	
Rp.18	T-18174	310	55	AD1490–1655	Picea	Top
Rp.18	T-18175	300	45	AD1520–1655	Picea	Base
Rp.20	T-18176	1035	95	AD895–1155	Pinus	
Rp.24	TUa-5801	1555	30	AD445–550	Pinus	
<i>Forundersøkelser 2001</i>						
1023823	T-15468	910	75	AD1025–1225	Picea	Stene 2001
1023970	T-15471	765	60	AD1225–1295	Picea	Stene 2001
1036643	T-15467	1070	75	AD890–1025	Pinus	Stene 2001
1023825	TUa-3265	845	65	AD1160–1275	Pinus	Stene 2001
1023969	T-15470	955	75	AD1015–1185	Pinus	Stene 2001
1023886	T-15469	890	65	AD1040–1225	Picea	Stene 2001

APPENDIX IIB Excavated and dated bloomery sites of the Hedmark tradition

Place	Id-nr	Year	Numb. sh	Method	Species	Dating		Source		
						Lab. Ref.	BP	±	Cal.	comment
Stor-Ebødal										
Koppang med Bakken	40115	1992	2	Test pit	Picea	T-10364	980	70	AD990–1155	Slag heap
nordre 13/95										Espelund, letter 27.09.1998
Rendalen										
Hangaard	19985	1990	2	Test pit	Pinus	T-8731	1030	60	AD970–1030	Slag heap
nordre 52/17										Espelund, letter 27.09.1998
Åmot										
Rødsmoen	R300	1994	1	Test pit	Pinus	T-11546	1020	70	975–1040	Slag heap
Rødsmoen	R300	1995–1996	1	Excavation	Pinus	T-12043	930	65	1025–1215	Slag heap
Rødsmoen	R677	1995–1996	–	Test pit	–	T-11549	920	95	1015–1230	Slag heap
Rødsmoen	R456	1995–1996	1	Excavation	Pinus	T-12047	880	50	1050–1225	Ore stockpile
Rødsmoen	R456	1995–1996	1	Excavation	30 betula, 6 pinus, 4 picea	T-12048	1005	70	990–1155	Isolation pit
Rødsmoen		1996								Narmo (1997) 41
Rødsmoen										Narmo (1997) 41
Rødsmoen										Narmo (1997) 41

APPENDIX IIB Excavated and dated bloomery sites of the Hedmark tradition (cont.)

Place	Id-nr	Year	Numb. sh	Method	Species	Dating		Source
						Lab. Ref.	comment	
evt anmet nr								
Rødsmoen	R305	1994	1	Test pit	Pinus	T-10993	790 ± 75 1170–1270	Slag heap Narmo (1997) 54, wrong in report, same dating used on R17a
Rødsmoen	R305	1995–1996	1	Excavation	Picea	T-12044	990 ± 45 1010–1150	Slag heap Narmo (1997) 54
Rødsmoen	R305	1995–1996	1	Excavation	Pinus	T-12045	845 ± 50 1165–1275	Isolation pit Narmo (1997) 54
Rødsmoen	R305	1995–1996	1	Excavation	Pinus	T-12046	850 ± 65 1065–1275	Isolation pit Narmo (1997) 54
Rødsmoen	R695	1995–1996	2	Test pit	Picea	T-11548	805 ± 80 1170–1285	Slag heap K1 Narmo (1997) 69
Rødsmoen	R695	1995–1996	2	Excavation	Picea	T-12049	830 ± 80 1165–1280	Slag heap K1 Narmo (1997) 69
Rødsmoen	R695	1995–1996	2	Excavation	Pinus	T-12050	1010 ± 75 980–1155	Slag heap K1 Narmo (1997) 69
Rødsmoen	R695	1995–1996	2	Excavation	Pinus/Picea	T-12051	1030 ± 65 975–1035	Slag heap K2 Narmo (1997) 69

Rødsmoen	R695	1995–1996	2	Excavation	Pinus	T-12052	1090	65	890–1015	Slag heap K2	Narmo (1997) 69
Rødsmoen	R17a	1995–1996	2	Excavation	Pinus	T-10993	790	75	1170–1270	Slag heap	Narmo (1997) 100, wrong in report, same dating used on R305
Rødsmoen	R17a		2		Pinus	Tua-1593	1000	50	1005–1040	Tapping furnace	Narmo (1997) 100
Rødsmoen	R17a	1995–1996	2		Pinus	T-12666	965	65	1015–1165	Isolation pit	Narmo (1997) 100
Rødsmoen	R17a	1995–1996	2		Pinus	T-12975	960	65	1015–1165	Isolation pit	Narmo (1997) 100
Rødsmoen	R17a	1995–1996	2		Pinus	Tua-1594	855	55	1160–1250	Slag heap K2	Narmo (1997) 100
Gråfjellom-rådet	Se vedlegg IIa										
Trysil											
Fjeldteigen 58/24 m.fl.	39958	1989	2	Test pit	Picea	T-8737	805	75	AD1165–1275	Slag heap	Espelund, letter 27.09.1998
Eberum											
Malmholtet	?	?	?	Test pit	Picea	T-10366	775	45	AD1225–1270	Slag heap	Espelund, letter 27.09.1998
Våler											
Risberget 81/37, 68	62320	2006	2	Test pit	Pinus	TUa-7032	1180	25	AD825–890	Slag heap	Espelund, letter 04.10.2007

<i>Løten</i>	?	?	?	Pinus/Picea	T-9397	1110	80	AD860–1010	Bloomery site	Larsen/Rølfesen in prep.
Korperud?	?		?	Picea	T-9398	880	65	AD1035–1230	Smithie?	
Narsetra?	?		?	Picea	T-9399	985	40	AD1010–1040	Charcoal pit?	
Løten	Site L.60	1992–93	1	Test pit	T-11123	885	75	AD1035–1250	Slag heap/4A	Bårdseng (1998)
allmenning										
<i>Ringsaker</i>										
Hamarstø	F/1	1994	2	Test pit	Beta-79588	920	50	1035–1195	Slag heap	Bårdseng (1998)
Bøverlund	F/2	1994	2 + 2	Test pit	Beta-79589	780	60	1220–1285	Slag heap	
Tomseter	F/3	1994	2	Test pit	Beta-79590	850	50	1165–1260	Slag heap	
Storstilen	F/5	1994	2	Test pit	Beta-79592	1040	60	975–1030	Slag heap	
Suljulia	F/6	1994	4	Test pit	Beta-79593	870	60	1055–1245	Slag heap	
Åsta	F/7	1994	2	Test pit	Beta-79594	860	60	1065–1250	Slag heap	
Grimstilen	F/8	1994	2	Test pit	Beta-79595	880	60	1045–1235	Slag heap	

APPENDIX IIB Excavated and dated bloomery sites of the Hedmark tradition (cont.)

Place	Id-nr	Year	Numb. sH	Method	Species	Dating		Source		
						Lab. Ref.	BP ± Cal.			
evt annet nr										
Hamar										
Vang	V.537	1992-93	2	Test pit	Pinus	T-11124	905	70 AD1030-1225	Slag heap	(Bårdseng 1998)
allmenning										
Vang	V.232	1992-93	1	Test pit	Pinus	T-11125	720	80	1255-1380	Slag heap/4A
allmenning										
Vang	V.162	1992-93	2 (Horse shoe, variant)	Test pit	Pinus	T-11127	975	60	1010-1160	Slag heap/3B
allmenning										
Vang	V.104	1992-93	2	Test pit	Pinus	T-11128	725	95	1230-1385	Slag heap/4B
allmenning										
Vang	V.97	1992-93	2 (Horse shoe, variant)	Test pit	Pinus	T-11129	970	80	1005-1170	Slag heap/3B
allmenning										
Vang	V.521	1992-93	1	Test pit	Pinus	Tua-730	825	65	1170-1280	Slag heap/4A
allmenning										
Vang	V.210	1992-93	2	Test pit	Pinus	Tua-731	835	70	1165-1280	Slag heap/4B
allmenning										
Vang	V.6	1992-93	2 (Hestesko, variant)	Test pit	Pinus	Tua-732	875	70	1045-1250	Slag heap/3B
allmenning										
Vang	V.57	1992-93	?	Test pit	Pinus	T-10383	945	65	1015-1165	?
allmenning										

Vang allmenning	V.58	1992-93	2 (Hesteko, variant)	Test pit	Pinus	T-10384	995	40	1000-1035	Slag heap/3A
Vang allmenning	V.190	1992-93	3(Hesteko, variant)	Test pit	Pinus	T-10386	975	105	970-1170	Slag heap/3A
Vang allmenning	V.191	1992-93	2	Test pit	Pinus	T-10387	895	65	1030-1220	Slag heap/4B
Vang allmenning	V.254	1992-93	1	Test pit	Bet./Salix	T-10388	1025	150	880-1170	Slag heap/4A
Vang allmenning	V.256	1992-93	?	Test pit	Pinus	T-10389	875	65	1040-1230	?
Vang allmenning	V.296	1992-93	?	Test pit	Pinus	T-10390	795	65	1185-1275	?
Vang allmenning	V.310	1992-93	2	Test pit	Pinus	T-10391	925	50	1025-1170	Slag heap/4B
Vang allmenning	V.397	1992-93	1	Test pit	Pinus	T-10392	1005	65	980-1040	Slag heap/4A
<i>Värmland</i>										
Torsby kommune	Östmark 421:1	1996-97	1	Test trench	-	Ua 13412	975	70	AD1008- 1155	Slag heap Myrdal-Runebjer (1999)
Torsby kommune	Östmark 190:1	1996-97	1	Test trench	-	Ua 13413	1040	60	AD917-1102	Slag heap
Torsby kommune	Östmark 194:1	1996-97	1	Test trench	-	Ua 13411	1055	70	AD899-1092	Slag heap
Torsby kommune	Lekvatnet 174:1	1996-97	2	Test trench	-	Ua 13414	925	70	AD1040- 1190	Slag heap

APPENDIX IIB Excavated and dated bloomery sites of the Hedmark tradition (cont.)

Place	Id-nr	Year	Numb. sH	Method	Species	Dating				Source
						Lab. Ref.	BP	±	Cal.	
Torsby kommune	Dalby 322:U	1990–91	2	Test pit	–	Lu 4053	960	70	AD1014– 1168	Slag heap Svensson (1998)
Torsby kommune	N. Finnskoga 63	1990–91	1	Test pit	–	ST 12620	925	70	AD1040– 1190	Slag heap
Torsby kommune	S. Finnskoga 125	1990–91	3	Test pit	–	ST 12689	855	70	AD1071– 1240	Slag heap
Torsby kommune	S. Finnskoga 17	1990–91	2	Test pit	–	ST 12887	1070	195	AD765–1151	Slag heap
Torsby kommune	N. Finnskoga 224	1990–91	3	Test trench	–	ST 13544	995	60	AD999–1139	Slag heap
Torsby kommune	N. Finnskoga 235	1990–91	2	Test pit	–	ST 13545	1030	50	AD961–1106	Slag heap
Torsby kommune	S. Finnskoga 135	1990–91	2(3)	Test trench	–	ST 13546	1120	40	AD875–971	Slag heap
Torsby kommune	N. Finnskoga 217	1990–91	2	Test pit	–	ST 13547	1005	50	AD996–1129	Slag heap
Torsby kommune	S. Finnskoga 569	1990–91	2	Test pit	–	ST 13548	940	65	AD1034– 1178	Slag heap

Torsby kommune	S. Finnskoga 573	1990–91	4	Test pit	–	ST 13550	1125	50	AD836–970	Slag heap
Torsby kommune	S. Finnskoga 318	1990–91	3	Test pit	–	ST 13553	980	40	AD1019– 1137	Slag heap
Torsby kommune	S. Finnskoga 281	1990–91	3	Test pit	–	ST 13554	955	40	AD1033– 1144	Slag heap
Torsby kommune	S. Finnskoga 382	1990–91	2	Test pit	–	ST13866	950	45	AD1035– 1152	Slag heap
Torsby kommune	N. Ny 483	1990–91	2	Test pit	–	ST13871	1015	65	AD972–1130	Slag heap
Torsby kommune	Dalby 601	1990–91	2	Test pit	–	Ua 2523	940	75	AD1030– 1183	Slag heap
Torsby kommune	S. Finnskoga 56	1990–91	1	Test pit	–	Ua 2526	1280	55	AD691–836	Slag heap
Torsby kommune	S. Finnskoga 321	2	3	Test pit	–	Ua 2529	1285	70	AD684–849	Slag heap
Torsby kommune	S. Finnskoga 397	1990–91	2	Test pit	–	Ua 2530	1655	70	AD305–503	Slag heap

APPENDIX IIC *Excavated and dated charcoal pits of the Hedmark tradition*

<i>Place</i>	<i>Id-nr</i>	<i>Year</i>	<i>No.</i>	<i>Method</i>	<i>interpr.</i>	<i>Species</i>
	<i>evt other No</i>					
<i>Stor-Elvdal</i>						
Tresen 19/7	46576, 92113	2005	2	Sectioning	Rectangular Square	Pinus
S.Blæsterbekken	40115	1993	1	Test pit	–	Picea
<i>Åmot</i>						
Kåsa 30/56	Anr. 98/162	1998	1	Sectioning	Square	Pinus
Osvold Nordre 63/1	91442-44	2006	3	Sectioning	Square	Pinus
Åset 5/15	20469	2007	1	Sectioning	Rectangular	Pinus
Rena 8/97, 110, 143	c52745	2001	1	?	?	Pinus
Bråthen 1/7	?	1996	1	Sectioning	Square	Picea salix/ populus
Gråfjellområdet	Se vedlegg IIa					
Rødsmoen	R293	1995–1996	1	Sectioning	Square	Pinus
Rødsmoen	R296	1995–1996	1	Sectioning	Square	Pinus/Picea
Rødsmoen	R306	1995–1996	1	Sectioning	Rectangular	Pinus/Picea
Rødsmoen	R687	1995–1996	1	Sectioning	Rectangular	Pinus
Rødsmoen	R692	1995–1996	1	Sectioning	Square	Pinus
Rødsmoen	R703	1995–1996	1	Sectioning	Square	Pinus/Picea
Rødsmoen	R292	1995–1996	1	Sectioning	Rectangular	Picea
Rødsmoen	R706	1995–1996	1	Test pit	–	Picea
Rødsmoen	R20	1995–1996	1	Sectioning	Square	Pinus
Rødsmoen	R15a	1995–1996	1	Sectioning	Square	Pinus
Rødsmoen	R14	1995–1996	1	Sectioning	Square	Pinus
Rødsmoen	R31	1995–1996		Test pit	Round?	Pinus
<i>Trysil</i>						
Bæk 53/39	129476	2010	1	Sectioning	Square	Pinus
Bæk 53/39	129476	2010	1	Sectioning	Square	Pinus

<i>Dating</i>					<i>Source</i>
<i>Lab. Ref.</i>	<i>BP</i>	$\pm$	<i>Cal.</i>	<i>Comment</i>	
T-18462	905	60	AD1035–1220		
T-18463	830	75	AD1165–1280		
T-10365	695	65	AD1265–1375		Espelund, letter 27.09.1998
T-13922	830	65	AD1165–1280		Rytter (1998)
T-19017	780	75	AD1215–1290		Bergstøl (2007)
T-19018	910	45	AD 1035–1210		
T-19019	805	50	AD1215–1280		
T-19306	855	50	AD1165–1250	BaseIn the wall	Nybruget/Rolfsen (2009)
T-19307	915	75	AD1025–1220		
T-15813	885	65	AD1040–1230		Amundsen (2002b)
T-13578	790	45	AD 1220–1285	Kp 2 is from a sekundary phase	Larsen (1998)
T-13579	395	65	AD 1440–1630		
T-12029	920	80	1020–1220		Narmo (1997) 81
T-12030	1020	80	975–1155		Narmo (1997) 81
T-12031	645	45	1285–1405		Narmo (1997) 81
T-12034	865	65	1050–1255		Narmo (1997) 81
T-12035	825	50	1180–1275		Narmo (1997) 81
T-12036	925	40	1035–1175		Narmo (1997) 81
T-11544	875	100	1030–1280	The base of the pit	Narmo (1997) 81
T-11545	955	80	1010–1185	The base of the pit	Narmo (1997) 81
T-12974	910	65	1030–1220		Narmo (1997) 109
T-12976	945	40	1030–1165		Narmo (1997) 109
T-10994	805	65	1170–1270		Narmo (1997) 109, Bergstøl (1997) 62
T-12136	795	80	1185–1290	Originally hunting pit	Narmo (1997) 109, Bergstøl (1997) 62
TRa-1880	805	30	AD1220–1275	The base of the pit	Gundersen
TRa-1881	855	30	AD1170–1230	Eastern embankment	(2011a)

APPENDIX IIC *Excavated and dated charcoal pits of the Hedmark tradition (cont.)*

<i>Place</i>	<i>Id-nr</i>	<i>Year</i>	<i>No.</i>	<i>Method</i>	<i>interpr.</i>	<i>Species</i>
<i>evt other No</i>						
<i>Våler</i>						
Snarhol 52/8	Fornmnr 669	1999	1	Test pit	Square	Pinus
Audneby 51/20	c52632	2001	4	Sectioning	Rectangular	?
Audneby 51/18	91666,1-7	2005	3 (7)	Test pit	Squaree	Pinus
Kavlerud 40/1, 345	90463,1-5	2005	2 (5)	Test pit (1) Sectioning (1)	Squaree	Pinus
Sjurderud 34/1	91236-37	2007	12	Sectioning (6) Test pit (6)	Squaree	Pinus
Svenneby 38/1	c52631	2001	5 (10)	Sectioning	Rectangular	?
<i>Elverum</i>						
Svartholtet	?	1973	1	?	?	?
Grundset S. og Ø. 14/1, 216	?	1984	5(26)	Sectioning	Square/ Rectangular	?
Grundset 14/3	88081, 88083, 88086, 88087	2005	4	Sectioning (1)/ Test pit (3)	Square	Pinus
Lømo 72/114	90989	2005	1	Sectioning	Destroyed	Pinus
Elverum prestegård 31/25	?	1984	1	Sectioning	Square	

<i>Dating</i>					<i>Source</i>
<i>Lab. Ref.</i>	<i>BP</i>	$\pm$	<i>Cal.</i>	<i>Comment</i>	
				Not dated	?
T-15641	865	80	AD1045-1275	R4, from the base	Tønnessen (2001a)
T-15642	900	45	AD1045-1215	R4, charc. below the embankment	
T-15643	935	40	AD1030-1165	R6, from the base	
T-18613	945	75	AD1015-1200		Bøckman (2007)
T-18614	960	65	AD1015-1170	R1, from the base	
T-18615	980	65	AD1010-1160	R1, phase 2?	
T-18616	770	65	AD1225-1290	R2, bunnstokk	
				R3, from the base	
T-18611	790	65	AD1215-1285	R1, from the base	Bøckman (2008)
T-18612	825	75	AD1165-1280	R5, from the base	
Beta-242408	840	50	AD1040-1270	91236, R2, from the base	Demuth/Bergstøl
Beta-242412	910	60	AD1020-1260	91236, R8, from the base	(2007)
Beta-242413	920	50	AD1010-1220	91236, R10, from the base	
Beta-242414	820	40	AD1160-1270	9123?, R14, from the base, test pit	
Beta-242415	900	60	AD1010-1260	91237, R15, from the base	
Beta-242416	1000	60	AD970-1200	9132?, R21, from the base, test pit	
Beta-242417	860	40	AD1040-1240	91237, R22, from the base	
Beta-242418	830	40	AD1050-1260	91237, R26, from the base	
T-15644	765	40	AD1245-1290		Tønnessen
T-15645	935	40	AD1030-1165		(2001b)
T-15646	750	50	AD1250-1295		
T-2330	880	70	1040-1220		Bloch-Nakkerud
					(1987) 65
T-6051	1090	50	AD895-985	Pit 46, log from the base	Mikkelsen (1986)
T-6053	890	60	AD1040-1210	Pit 57	
T-6055	940	70	AD1020-1160	Pit 62	
T-18685	810	75	AD1170-1285	Id 88081	Holm/Berg-Han-
T-18688	1070	50	AD900-1015	Id 88083	sen (2007)
T-17950	980	75	AD1000-1165	Collectet	Bergstøl (2005)
					Fjeld (1984)

APPENDIX IIC *Excavated and dated charcoal pits of the Hedmark tradition (cont.)*

<i>Place</i>	<i>Id-nr</i>	<i>Year</i>	<i>No.</i>	<i>Method</i>	<i>interpr.</i>	<i>Species</i>
<i>evt other No</i>						
Elverum prestegård 31/25 m.fl.	Anr. 98/174	1998	8	Sectioning (4)/ Test pit (4)	Square/ Rectangular	Pinus
Elverum prestegård 31/94, 142	c51074 c51075	1997	2	Sectioning	Square/ Rectangular	Pinus
Elverum prestegård 31/1	c51076 c51077 c51078 c51079	1997	4	Sectioning (2)/ Test pit (2)	Square/ Rectangular	Pinus
Grindalen 13/?	c37849	1989	3	Sectioning	Square	
Grindalen 13/873	91743-1,2,4,5,9	2006	5	Test pit	Square	Pinus
Grindalen 13/13	c53150/51	2003	3	Sectioning	Square	Pinus
Murud 4/1	c38634	1994	1	Sectioning, overpløyd		
Gaarder 30/1090	c52870	2002	2	Test pit	Square/ Rectangular	Pinus
Gaarder 30/1	102640	2004	1	Test pit	Square	Pinus
Hagen 10/5 Skirbekk 9/1	c52312	1999	11	Sectioning (7)/ Test pit (4)	Square/ Rectangular	Pinus

<i>Dating</i>					<i>Source</i>
<i>Lab. Ref.</i>	<i>BP</i>	$\pm$	<i>Cal.</i>	<i>Comment</i>	
T-13897	870	40	AD1160–1225	R1	Trinterud (1998)
T-13898	770	45	AD1235–1290	R5	
T-13899	725	55	AD1270–1300	R10	
T-13900	890	40	AD1050–1215	R12	
T-14133	1090	45	AD895–1010	R9	
T-13283	840	65	AD1165–1275	R1, from the base	Stensgaard 1997a
T-13284	730	65	AD1255–1300	R3, from the base	
T-13287	930	40	AD1030–1170	R1, from the base	Stensgaard (1997b)
T-13288	775	65	AD1220–1290	R8, Test pit	
T-13289	1115	50	AD885–995	R9, from the base	
T-13290	905	60	AD1035–1220	R11, Test pit	
					Fossum (1989)
T-18819	975	50	AD1015–1155	R9,R5,R4,	Csisar/Berg-Hansen (2006)
T-18820	1015	75	AD975–1155		
T-18821	930	40	AD1030–1170		
T-17085	835	65	AD1165–1280	R1R7	Damlien/Berg-Hansen (2006)
T-17086	910	65	AD1030–1220		
					Gustafson (1994)
T-16199	665	75	AD1285–1395	R2	Amundsen (2002a)
T-17561	1010	50	AD995–1035	R3	Paulsen (2005)
T-14266	745	60	AD1250–1295	R1 (10/5)	Ristvedt (1999)
T-14269	850	45	AD1165–1255	R2 (9/1) phase 2	
T-14270	915	50	AD1035–1210	R2 (9/1) phase 1	
T-14271	825	50	AD1185–1275	R2 (10/5) phase 1	
T-14272	870	80	AD1040–1265	R2 (10/5) phase 2	
T-14273	760	80	AD1220–1300	R3 (10/5)	
T-14274	655	75	AD1285–1400	R4 (10/5)	
T-14275	905	80	AD1030–1230	R5B (10/5)	
T-14277	935	65	AD1020–1210	R5D (10/5) phase 3	
T-14278	790	80	AD1200–1290	R5E (10/5)	
T-14280	960	80	AD1010–1175	R6 (10/5)	
T-14281	940	80	AD1015–1215	R7 (10/5) phase 1	

APPENDIX IIC *Excavated and dated charcoal pits of the Hedmark tradition (cont.)*

<i>Place</i>	<i>Id-nr</i>	<i>Year</i>	<i>No.</i>	<i>Method</i>	<i>interpr.</i>	<i>Species</i>
<i>evt other No</i>						
Hanstad-Helset	?	1988	2	Sectioning	Square	?
Helset 34/23	Anr. 98/127	1998	1	Sectioning	Rectangular	Pinus
Hornmoen 153/121	91083, 85, 87	2006	3	Test pit	Square	Pinus
Houm Søndre	115905	2009?	1			
Mastemoen	?	1987, 1988	7	Sectioning/ spits	Square	?
Mastemoen øst 30/1	?	1998	1	Test pit	Square	–
<i>Åsnes</i>						
Lindberget 10/5, 7, 9	Anr. 95/81	1995	2	Test pit	Rectangular/ Oblong?	Pinus
Sætre nordre 199/61	40679/1	2010	1	Sectioning		Pinus
Sætre nordre 199/61	40679/1	2010	1	Sectioning		Pinus
<i>Grue</i>						
Piksrud 51/?	?	1995	1	–	–	Pinus
<i>Løten</i>						
Norderhov 17/1	99944		1	Sectioning	Square	Pinus
Løten prestegård 20/1 m.fl	97795-2, 97797	2007	2	Sectioning	Square	Pinus
Ånestad ind. område (Kjøs 123/–)	?	1985	2	Sectioning	Square	–
Nordbygda?	?	2006	1	Test pit	?	?
<i>Kongsvinger</i>						
Lier 24/1 og Stengelsrud 17/1,2	c53212-20	2003	8		Square/ Rectangular	Pinus

<i>Dating</i>					<i>Source</i>
<i>Lab. Ref.</i>	<i>BP</i>	$\pm$	<i>Cal.</i>	<i>Comment</i>	
T-14282	735	65	AD1250–1300	R7 (10/5) phase 2	
T-14283	830	40	AD1190–1270	R8 (10/5)	
T-8657	860	60	AD1050–1240	R2	Fossum (1988)
T-8658	990	80	AD980–1150	R1	
Beta-123798	890	50	AD1025–1260	R1	Pedersen (1998)
T-18831	775	60	AD1220–1290	R16	Csisar/Berg-
T-18832	920	60	AD1030–1215	R3	Hansen (2006)
T-18833	845	40	AD1170–1250	R5	
T-20072	805	65	AD1195–1285	R1	Bergstøl in prep.
T-8651	1020	60	AD970–0130	R4	Fossum (1987)
T-8652	860	60	AD1050–1240	R5	and (1988)
T-8653	880	50	AD1050–1220	R6	
T-8654	880	80	AD1030–1250	R7	
T-8655	1070	70	AD890–1020	R8	
T-8656	930	60	AD1020–1180	R9	
–	–	–	–	–	Holm (1998)
Beta-83434	810	60	AD1055–1295	Nr. 40	Gustafson (1995)
Beta-83435	840	70	AD1030–1290	Nr.41A	
Tra-1627	900	30	AD1050–1210		Gundersen
Tra-1628	1085	35	AD900–1005		(2011b)
T-12472	1080	50	AD895–1015		Larsen in prep.
T-19770	820	75	AD1165–1280	phase 1	Bergstøl in prep.
T-19771	790	75	AD1210–1290	phase 2	
TUa-7199	875	25	AD1165–1220		Mjærum and Berg-
T-19456	950	40	AD1025–1165		Hansen (2008)
–	–	–	–		Walhovd (1985)
Beta-224836	980	50	AD1010–1140	?	Bueklev (2006)
TUa-4650	1055	40	AD975–1020	R12	Reitan/Berg-Han-
T-17035	980	65	AD1010–1160	R28a	sen (2003/2006)

APPENDIX IIC *Excavated and dated charcoal pits of the Hedmark tradition (cont.)*

<i>Place</i>	<i>Id-nr</i>	<i>Year</i>	<i>No.</i>	<i>Method</i>	<i>interpr.</i>	<i>Species</i>
	<i>evt other No</i>					
<i>Ringsaker</i>						
Børke Nordre 30/3	c52874	2002	1	Sectioning	?	Betula
Halset 791/1	Id-U27396?	2000	1	Sectioning	Square	Picea
	C52900					
Mo 378/?	Anr. 87/103	1987	2	Sectioning	Square/ Round?	Pinus
Stolpestad nordre 230/1	Anr. 87/102	1987	2	Sectioning	Square	Picea
Østberg (gård?)	?	?	1?	?	?	?
<i>Hamar</i>						
Imerslund østre 30/1	115864	2008	1	Test pit	Square	–
Kirkeby 49/43	Anr. 98/182	1998	1	Sectioning	Rectangular	Picea
Narmo 33/3	014665? Anr. 00/119	2000	1	Sectioning	Square	Picea
Valum	?		1	Spits	?	?
<i>Värmland</i>						
Torsby kommune	S. Finnskoga 135	1990–91	1			
Torsby kommune	Gunarskog 173:1	1990–92	1	?	Square?	?
Torsby kommune	Dalby 81:2	1990–93	1	?	Square?	?
Torsby kommune	S. Finnskoga 222	1990–94	1	?	Square?	?
Torsby kommune	Dalby 545	1990–95	1	?	Square?	?
Torsby kommune	S. Finnskoga 75	1990–96	1	?	Square?	?
Torsby kommune	S. Finnskoga 77	1990–97	1	?	Square?	?
Torsby kommune	N. Finnskoga 224	1990–98	1	?	Square?	?

<i>Dating</i>					<i>Source</i>
<i>Lab. Ref.</i>	<i>BP</i>	$\pm$	<i>Cal.</i>	<i>Comment</i>	
T-16372	715	75	AD1265–1380		Lislerud (2003)
T-14870	740	65	AD1245–1305	Burned log in the top	Omeland (2000a)
T-14871	760	65	AD1225–1295	from the base	
T-9193	645	50	AD1280–1390	R1R2	Strømme (1987a)
T-9194	800	45	AD1210–1265		
T-9191	650	65	AD1275–1395	R1R2	Strømme (1987b)
T-9192	940	70	AD1015–1170		
T-10272	750	75	AD1220–1285		Skjeseth (1993)
Beta-246088	340	40	AD1450–1650		Holseng (2008)
—	—	—	—		Stene (1998)
T-14868	810	40	AD1215–1280	Burned log in the top	Omeland (2000b)
T-14869	765	85	AD1210–1300	From the base	
T-11110	1030	65	AD975–1030		Pilø (2005) 112
Lu 3552	890	60	AD1058–1209		
Lu 4004	570	60	AD1310–1427		
Lu 4232	220	80	AD1641–1954		
ST 12688	1010	70	AD974–1136		
ST 12890	900	70	AD1050–1206		
ST 19102	780	70	AD1166–1280		Svensson (1998)
ST 13014	1540	150	AD341–636		
ST 13872	1000	45	AD1001–1131		

APPENDIX IIC *Excavated and dated charcoal pits of the Hedmark tradition (cont.)*

<i>Place</i>	<i>Id-nr</i>	<i>Year</i>	<i>No.</i>	<i>Method</i>	<i>interpr.</i>	<i>Species</i>
<i>evt other No</i>						
Torsby kommune	N. Finnskoga 30	1990–99	1	?	Square?	?
Torsby kommune	Dalby 322	1990–100	1	?	Square?	?
Torsby kommune	S. Finnskoga 220	1990–101	1	?	Square?	?
Torsby kommune	N. Finnskoga 35	1990–102	1	?	Square?	?

<i>Dating</i>				<i>Source</i>
<i>Lab. Ref.</i>	<i>BP</i>	$\pm$	<i>Cal.</i>	<i>Comment</i>
ST 14153	720	50	AD1252–1363	
ST 14167	870	50	AD1072–1226	
Ua 2528	1005	55	AD993–1133	
Ua 2531	1465	70	AD494–638	

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
<i>Excavated sites</i>						
Jfp.1	Slagghaug 1	4.15	2.2	0.9	17.2	18.7
Jfp.1	Slagghaug 2	1.3	0.8	0.4	0.9	—
Jfp.1	Slaggvoll 1	1.3	0.9	0.15	0.4	—
Jfp.1	Slaggvoll 2	4.3	1.8	0.1	1.6	—
Jfp.1	Slagglag	1	0.8	0.15	0.3	—
Jfp.2	Slagghaug 1	2.9	2	0.5	6.1	—
Jfp.2	Slagghaug 2	3.25	1.95	0.3	4.0	—
Jfp.3	Slagghaug 1	3.3	2.5	0.7	12.1	5.5
Jfp.3	Slagghaug 2	3	2.25	0.7	9.9	7.7
Jfp.3	Slagghaug 3	2.9	2.7	0.1	1.6	1.5
Jfp.3	Slagghaug 4	2.5	2.4	0.1	1.3	1.8
Jfp.4	Slaggutkast	3.4	2	0.3	4.3	6
Jfp.5	Slagghaug 1	4	3	0.9	22.6	14.1
Jfp.5	Slagghaug 2	3.3	4.1	0.7	19.8	11
Jfp.5	Slagghaug 3	2.8	2.2	0.6	7.7	4.5
Jfp.5	Slagghaug 4	2.2	1.5	0.8	5.5	2.6
Jfp.5	Slagghaug 5	2.6	1	0.2	1.1	1.2
Jfp.5	Slagghaug 6	2	1.7	0.2	1.4	1
Jfp.6	Slagghaug 1	3.5	1.5	0.5	5.5	7.1
Jfp.6	Slagghaug 2	2.7	2.4	0.3	4.1	5
Jfp.7	Slagghaug 1	1.5	1.5	0.25	1.2	1.5
Jfp.8	Slagghaug 1	2.8	2.2	0.6	7.7	4.7
Jfp.8	Slagghaug 2	1.5	1	0.2	0.6	6,5*
Jfp.8	Slagghaug 4	2.5	3	0.3	4.7	
Jfp.8	Slagghaug 3	2.6	2.4	0.4	5.2	2.9
Jfp.9	Slagghaug 1	4.9	2.7	1	27.7	14.3
Jfp.9	Slagghaug 2	3	3.4	0.35	7.5	4.8
Jfp.9	Slagghaug 3	2.5	2.7	0.35	4.9	3

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
<i>Numbers in italic in column Weight is measured values.</i>						
<i>Normale numbers is calculated means</i>						
483.4	368.5	25.4	27.5	33.3	36.1	
459.5	293.8	1.0	—	1.6	—	
459.5	293.8	0.4	—	0.7	—	
459.5	293.8	1.9	—	3.0	—	
459.5	293.8	0.3	—	0.5	—	
459.5	293.8	7.1	—	11.2	—	
459.5	293.8	4.7	—	7.3	—	
478.5	293.8	14.2	5.9	23.2	10.5	
551	293.8	11.6	9	21.8	17	
459.5	293.8	1.9	4.7	3.0	2.8	
459.5	293.8	1.5	2.1	2.3	3.3	
459.5	293.8	5.0	7.1	7.8	11.0	
480	293.8	26.6	16.6	43.4	27	
483.5	293.8	23.3	12.9	38.3	21.3	
459.5	293.8	9.1	5.3	14.2	8.3	
459.5	293.8	6.5	3.1	10.2	4.8	
459.5	293.8	1.3	1.4	2.0	2.2	
459.5	293.8	1.7	1.2	2.6	1.8	
440	271	5.9	7.7	9.6	12.5	
370	239	3.9	4.8	6.1	7.4	
412	293.8	1.4	1.8	2	2.5	
459.5	293.8	9.1	5.5	14.2	8.6	
423	293.8	0.7	7.6	9	11	*Volume calculation with total station is measured on both slag heaps
459.5	293.8	5.5				
459.5	293.8	6.1	3.4	9.6	5.3	
500	338	37.5	19.3	55.4	28.6	
459.5	293.8	8.8	5.6	13.7	8.8	
459.5	293.8	5.8	3.5	9.1	5.5	

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps (cont.)*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
Jfp.9	Slagghaug 4/1*	1.2	2.1	0.15	0.8	0.5
Jfp.9	Slagghaug 4/2	1.2	0.8	0.15	0.3	
Jfp.10	Slaggutkast	3.5	2.2	0.5	8.1	5
Jfp.11	Slagghaug 1	3.3	1.2	0.3	2.5	1.7
Jfp.11	Slagghaug 2	1	0.3	0.15	0.1	0.5*
Jfp.11	Slagghaug 3	1	0.8	0.1	0.2	
Jfp.12	Slaggutkast	2	1.7	0.25	1.8	1.5
Jfp.12	Slagghaug 1	4.3	2.1	0.8	15.1	11.6
Jfp.12	Slagghaug 2	4.6	2.8	0.9	24.3	17.6
Jfp.12	Slaggutkast ved SH2	1.5	1.1	0.3	1.0	1
Jfp.12	Slagghaug 3	3.3	2.6	0.5	9.0	10.6
Jfp.12	Slagghaug 4	3.2	1.7	0.35	4.0	6.7
Jfp.12	Slagkonsentrasjon	1.5	1.1	0.1	0.3	
Jfp.13	Slagghaug 1	3.1	2.3	0.6	9.0	5.3
Jfp.13	Slagghaug 2	1.8	1.8	0.8	5.4	2.9
Jfp.14	Slagghaug 1 + 3*	5.5	3	0.9	31.1	23.3 (SH1) + 4 (SH3) = 27.3
Jfp.14	Slagghaug 1, voll 1	3.1	1	0.4	2.6	3
Jfp.14	Slagghaug 1, voll2	1.6	1.3	0.3	1.3	1.4
Jfp.14	Slagghaug 2	4	2.7	1	22.6	11.6
Jfp.15	Slagghaug 1*	3.3	1.1	0.45	3.4	0.7
Jfp.15	Slagghaug 2	2.5	1.9	0.4	4.0	2.5
Jfp.16	Slagghaug 1	2.7	2.5	0.3	4.2	3.5
Jfp.17	Slagghaug 1	2	1.8	0.15	1.1	<1
Jfp.18	Slaggutkast	0.9	0.5	0.15	0.1	0.4
Jfp.19	Slagghaug 1	3.7	2.2	1	17.0	10.3
Jfp.19	Slagghaug 1, voll	1.3	1.2	0.3	1.0	0.3

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
459.5	293.8	0.9	0.6	1.5	0.9	*Defined as 1 slag heap som en slagghaug when it extended over the furnace
459.5	293.8	0.4		0.6		
459.5	293.8	9.5	5.9	14.8	9.2	*Measured together
459.5	293.8	2.9	2.0	4.6	3.1	
459.5	293.8	0.1	0.6	0.2	0.9	
459.5	293.8	0.2		0.3		
459.5	293.8	2.1	1.8	3.3	2.8	
459.5	293.8	17.8	13.6	27.8	21.3	
459.5	293.8	28.5	20.7	44.6	32.3	
459.5	293.8	1.2	1.2	1.9	1.8	
459.5	293.8	10.6	12.5	16.5	19.5	
459.5	293.8	4.7	7.9	7.3	12.3	
459.5	293.8	0.4	6.2	0.6	0.0	
459.5	293.8	10.5		16.5	9.7	
459.5	293.8	6.4		10.0	5.3	
502	293.8	36.5	32.1	62.5	54.8	SH3 lay under SH1 and cantbe taken out when calculat- ing. They are both measured.
459.5	293.8	3.0	3.5	4.8	5.5	Destroyed, calculaion based on the extent
459.5	293.8	1.5	1.6	2.4	2.6	
459.5	293.8	26.6	13.6	41.6	21.3	
459.5	293.8	4.0	0.8	6.3	1.3	
459.5	293.8	4.7	2.9	7.3	4.6	
406	151	2.5	2.1	5.7	6.8	
459.5	293.8	1.3	<1,1	2.1	<1,8	
459.5	293.8	0.2	0.5	0.3	0.7	
459.5	293.8	20.0	12.1	31.3	18.9	
459.5	293.8	1.2	0.4	1.8	0.6	

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps (cont.)*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
Jfp.19	Slagghaug 2	3.6	2.6	0.7	13.7	4.9
Jfp.19	Slagglag	2	1.2	0.15	0.8	
Jfp.20	Slagghaug 1	3.6	2.5	1	18.8	17
Jfp.20	Slagghaug 1, voll 1	1.4	1.4	0.22	0.9	
Jfp.20	Slagghaug 1, voll 2	1.6	1.5	0.25	1.3	
Jfp.20	Slagghaug 2	3.9	2.7	0.8	17.6	10
Jfp.20	Slagghaug 2, voll 1	1.5	1.5	0.17	0.8	
Jfp.20	Slagghaug 2, voll 2	1.1	4	0.3	2.8	
Jfp.21	Slagghaug 1	3	1.2	0.6	4.5	
Jfp.21	Slagghaug 2	3.5	1.5	0.2	2.2	
Jfp.22	Slagghaug 1	3	2.2	0.6	8.3	
Jfp.22	Slagghaug 2	2.5	1.5	0.8	6.3	
Jfp.23	Slagghaug 1	3.8	2.8	1.4	31.2	8.4
Jfp.23	Slagghaug 2	3	2.6	0.3	4.9	2
Jfp.23	Slagghaug 3	3	1.5	0.6	5.7	1.9
Jfp.24	Slagghaug 1	3	2	0.8	10.0	
Jfp.25	Slagghaug 1	3.5	1.7	0.6	7.5	
Jfp.25	Slagghaug 2	3	2.5	1.3	20.4	
Jfp.26	Slagghaug 1	2.7	2.2	1.3	16.2	
Jfp.26	Slagghaug 2	4	2	0.8	13.4	
Jfp.26	Slagghaug 2, voll 1	2	2	0.3	2.5	
Jfp.27	Slagghaug 1	1.7	1.2	0.3	1.3	
Jfp.28	Slagghaug 1	0.9	0.8	0.13	0.2	
Jfp.28	Slagggkonsentrasjon 1	3	2.4	0.34	5.1	
Jfp.28	Slagghaug 2	3	2.2	0.8	11.1	9
Jfp.28	Slagghaug 3	1.5	1.5	0.4	1.9	1
Jfp.28	Slagggkonsentrasjon 2	1.1	0.9	0.07	0.1	
Jfp.29	Slagghaug 1	3.8	2.1	0.5	8.4	3
Jfp.29	Slagghaug 2	3.1	3	0.8	15.6	
Jfp.30	Slagghaug 1	4.2	3.2	1.3	36.6	12.5
Jfp.30	Slagghaug 2	6	3.2	1	40.2	12.4
Jfp.30	Slagghaug 3	4.9	3	1.5	46.2	19
Jfp.30	Slagghaug 4	4.2	1.8	0.6	9.5	4.4

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
459.5	293.8	16.1	5.8	25.2	9.0	
459.5	293.8	0.9		1.4		
459.5	293.8	22.1	20.0	34.6	31.2	
459.5	293.8	1.1		1.7		
459.5	293.8	1.5		2.3		
459.5	293.8	20.7	11.8	32.4	18.4	
459.5	293.8	0.9		1.5		
459.5	293.8	3.2		5.1		
459.5	293.8	5.3		8.3		
459.5	293.8	2.6		4.0		
459.5	293.8	9.7		15.2		
459.5	293.8	7.4		11.5		
459.5	293.8	36.6	9.9	57.3	15.4	
459.5	293.8	5.8	2.4	9.0	3.7	
459.5	293.8	6.6	2.2	10.4	3.5	
459.5	293.8	11.8		18.5		
459.5	293.8	8.8		13.7		
459.5	293.8	24.0		37.5		
459.5	293.8	19.0		29.7		
459.5	293.8	15.7		24.6		
459.5	293.8	3.0		4.6		
459.5	293.8	1.5		2.4		
459.5	293.8	0.2		0.4		Mass weighted at the excavation (465,5 kg)
459.5	293.8	6.0		9.4		
475.5	355	15.8	12.8	21.1	17.1	
459.5	293.8	2.2	1.2	3.5	1.8	
459.5	293.8	0.2		0.3		
459.5	293.8	9.8	3.5	15.4	5.5	
459.5	293.8	18.3		28.6		
459.5	293.8	43.0	14.7	67.2	23.0	
459.5	293.8	47.2	14.6	73.9	22.8	
459.5	293.8	54.2	22.3	84.8	34.9	
459.5	293.8	11.2	5.2	17.5	8.1	

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps (cont.)*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
Jfp.31	Slagghaug 1	2.5	2	0.5	5.2	4.6
Jfp.31	Slagghaug 2	2.4	1.7	0.8	6.8	4.8
Jfp.32	Slagghaug 1	3.8	2.3	0.9	16.5	7.5
Jfp.32	Slagghaug 2	4.5	2.8	0.7	18.5	8
Jfp.32	Slagghaug 1, voll 1	1.8	1.1	0.5	2.1	2.1
Jfp.33	Slagghaug 1	2.8	1.5	0.5	4.4	3
Jfp.33	Slagghaug 2	3	2	0.4	5.0	3.4
Jfp.34	Slagghaug 1	2.8	1.8	0.6	6.3	3.6
Jfp.34	Slagghaug 2	2.3	1.1	0.3	1.6	1.8
Jfp.34	Slagghaug 1, voll 1	1.1	2	0.3	1.4	
Jfp.35	Slagghaug 1	1	0.5	0.5	0.5	
Jfp.36	Slagghaug 1	2.2	1.7	0.3	2.3	1.5
Jfp.36	Slagghaug 2	1.1	1	0.3	0.7	
Jfp.37	Slagghaug 1	1.2	1	0.2	0.5	
Jfp.37	Slagghaug 2	2.1	1.3	0.4	2.3	
Jfp.37	Slagghaug 3	2.3	1.3	0.4	2.5	
Jfp.38	Slagghaug 1	2	2	0.3	2.5	
Jfp.39	Slagghaug 1	6.6	2.6	0.6	21.6	8.4
Jfp.39	Slagghaug 2	5.3	3.2	0.9	32.0	11.2
<i>Not excavated sites</i>						
Id 1024847	Slagghaug 1	3.6	2.3	0.75	13.0	
Id 1024847	Slagghaug 2	3.5	2.3	0.7	11.8	
Id 1024863	Slagghaug 1	4.3	2.6	0.9	21.1	
Id 1024863	Slagghaug 2	5.2	4.5	0.65	31.8	
Id 1024867	Slagghaug 1	4.2	2.6	0.9	20.6	
Id 1024867	Slagghaug 2	4.3	2.5	0.94	21.2	
Id 1023587	Slagghaug 1	3.8	2.6	1.1	22.8	
Id 1023587	Slagghaug 2	3.2	2.2	0.7	10.3	
Id 1024712	Slagghaug 1	2.5	1.7	0.55	4.9	
Id 1024712	Slagghaug 2	1.2	1.2	0.55	1.7	
Id 1024719	Slagghaug 1	3.9	2.9	1	23.7	
Id 1024719	Slagghaug 2	2.6	2.6	0.9	12.7	
Id 1024408	Slagghaug 1	2.8	1.6	0.75	7.0	
Id 1024408	Slagghaug 2	3.1	2.2	0.95	13.6	

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
459.5	293.8	6.1	5.4	9.6	8.5	
459.5	293.8	8.0	5.6	12.6	8.8	
497	366	24.2	11	32.8	14.9	
459.5	293.8	21.7	9.4	33.9	14.7	
459.5	293.8	2.4	2.5	3.8	3.9	
459.5	293.8	5.2	3.5	8.1	5.5	
459.5	293.8	5.9	4.0	9.2	6.2	
459.5	293.8	7.4	4.2	11.6	6.6	
459.5	293.8	1.9	2.1	2.9	3.3	
459.5	293.8	1.6		2.5		
459.5	293.8	0.6		1.0		
459.5	293.8	2.8	1.8	4.3	2.8	
459.5	293.8	0.8		1.3		
459.5	293.8	0.6		0.9		
459.5	293.8	2.7		4.2		
459.5	293.8	2.9		4.6		
459.5	293.8	3.0		4.6		
406	226.7	19.6	8.9	35.1	13.6	Mass: 0,6 m3
444.6	326.7	41.8	14.6	56.9	19.9	Mass: 0,3 m3
459.5	293.8	15.3		23.9		
459.5	293.8	13.9		21.7		
459.5	293.8	24.7		38.7		
459.5	293.8	37.4		58.5		
459.5	293.8	24.2		37.8		
459.5	293.8	24.9		38.9		
459.5	293.8	26.7		41.8		
459.5	293.8	12.1		19.0		
459.5	293.8	5.7		9.0		
459.5	293.8	1.9		3.0		
459.5	293.8	27.8		43.5		
459.5	293.8	15.0		23.4		
459.5	293.8	8.3		12.9		
459.5	293.8	15.9		24.9		

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps (cont.)*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
Id 1024408	Slagghaug 3	3.5	1.2	0.5	4.4	
Id 1024419	Slagghaug 1	4	2.5	1.3	27.2	
Id 1024419	Slagghaug 2	2.9	5.1	1.3	40.2	
Id 1024367	Slagghaug 1	3.7	2.4	1.1	20.4	
Id 1024367	Slagghaug 2	3.3	2.4	0.85	14.1	
Id 1024695	Slagghaug 1	3	1.1	0.4	2.8	
Id 1024695	Slagghaug 2	2.6	2.1	0.55	6.3	
Id 1024684	Slagghaug 1	2.9	2	0.4	4.9	
Id 1024684	Slagghaug 2	2.5	1.7	0.68	6.0	
Id 1024298	Slagghaug 1	4	2.3	0.6	11.6	
Id 1024298	Slagghaug 2	4.3	2.6	0.8	18.7	
Id 1024652	Slagghaug 1	5.5	2.1	0.7	16.9	
Id 1024652	Slagghaug 2	3.3	1.7	0.5	5.9	
Id 1024625	Slagghaug 1	2.7	2.5	0.6	8.5	
Id 1024625	Slagghaug 2	3.8	2.2	0.4	7.0	
Id 1036510	Slagghaug 1	3.7	2.5	0.6	11.6	
Id 1036510	Slagghaug 2	4	2.7	0.55	12.4	
Id 1024445	Slagghaug 1	3.6	1.7	0.3	3.8	
Id 1024445	Slagghaug 2	4.1	2.8	0.7	16.8	
Id 1024395	Slagghaug 1	4.7	2.7	1.1	29.2	
Id 1024468	Slagghaug 1	4.4	2.2	1	20.3	
Id 1024468	Slagghaug 2	3.9	3	0.4	9.8	
Id 1024468	Slagghaug 3	2.5	1.2	0.3	1.9	
Id 1024468	Slagghaug 4	2.9	2	0.6	7.3	
Id 1023147	Slagghaug 1	4.9	2.5	1.2	30.8	
Id 1023147	Slagghaug 2	3.7	2.2	0.8	13.6	
Id 1023102	Slagghaug 1	3	1.8	0.7	7.9	
Id 1023102	Slagghaug 2	3	2.3	0.9	13.0	
Id 1023107	Slagghaug 1	3.4	2.3	1.3	21.3	
Id 1023107	Slagghaug 2					
Id 1023091	Slagghaug 1	3.6	2.3	0.75	13.0	
Id 1023091	Slagghaug 2	3.5	2.3	0.7	11.8	
Id 1023086	Slagghaug 1	3.6	3.1	1	23.4	
Id 1023086	Slagghaug 2	3.5	2	1	14.7	

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
459.5	293.8	5.2		8.1		
459.5	293.8	32.0		50.0		
459.5	293.8	47.3		74.0		
459.5	293.8	24.0		37.6		
459.5	293.8	16.6		25.9		
459.5	293.8	3.2		5.1		
459.5	293.8	7.4		11.6		
459.5	293.8	5.7		8.9		
459.5	293.8	7.1		11.1		
459.5	293.8	13.6		21.2		
459.5	293.8	22.0		34.4		
459.5	293.8	19.9		31.1		
459.5	293.8	6.9		10.8		
459.5	293.8	10.0		15.6		
459.5	293.8	8.2		12.9		
459.5	293.8	13.7		21.4		
459.5	293.8	14.6		22.9		
459.5	293.8	4.5		7.1		
459.5	293.8	19.8		30.9		
459.5	293.8	34.3		53.7		
459.5	293.8	23.8		37.2		
459.5	293.8	11.5		18.0		
459.5	293.8	2.2		3.5		
459.5	293.8	8.6		13.4		
459.5	293.8	36.2		56.6		
459.5	293.8	16.0		25.1		
459.5	293.8	9.3		14.5		
459.5	293.8	15.3		23.9		
459.5	293.8	25.0		39.1		
459.5	293.8					Measures not given
459.5	293.8	15.3		23.9		
459.5	293.8	13.9		21.7		
459.5	293.8	27.4		42.9		
459.5	293.8	17.2		26.9		

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps (cont.)*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
Id 1023163	Slagghaug 1	3.5	1.5	1.3	14.3	
Id 1023736	Slagghaug 1	4.8	2.6	1.3	34.0	
Id 1023736	Slagghaug 2	4.4	2.5	1.3	29.9	
Id 1023856	Slagghaug 1	3.5	1.8	0.6	7.9	
Id 1023856	Slagghaug 2	3	2.4	1	15.1	
Id 1023856	Slagghaug 3	1.7	1.7	0.6	3.6	
Id 1023202	Slagghaug 1	1.8	1.9	1.1	7.9	
Id 1023202	Slagghaug 2	2.5	1.7	1.2	10.7	
Id 1036846	Slagghaug 1	3.2	2.5	1	16.7	
Id 1023023	Slagghaug 1	2.8	2.3	0.9	12.1	
Id 1023023	Slagghaug 2	2.5	1.3	0.4	2.7	
Id 1023075	Slagghaug 1	2	2.2	0.4	3.7	
Id 1023760	Slagghaug 1	1.7	2.5	0.7	6.2	
Id 1023760	Slaggutkast	4.4	2.6	0.2	4.8	
<i>Protected sites</i>						
1023070	Slagghaug 1	1.9	1.9	0.9	6.8	
1023359	Slagghaug 1	4.2	2.2	1.2	23.2	
1023359	Slagghaug 2	4.1	2	1.05	18.0	
1023465	Slagghaug 1	3.2	1.8	0.75	9.0	
1023465	Slagghaug 2	4.5	2.7	1.2	30.5	
1023465	Slagghaug 3	1.3	1.3	0.3	1.1	
1023465	Slagghaug 4	0.9	0.9	0.2	0.3	
1023465	Slagghaug 5	1	1	0.3	0.6	
1023503	Slagghaug 1	1.6	1.5	0.3	1.5	
1023503	Slagghaug 2	1	1	0.2	0.4	
1023680	Slagghaug 1	4	1.8	0.95	14.3	
1023680	Slagghaug 2	2	3	0.85	10.7	
1023716	Slagghaug 1	5	2.3	1.1	26.5	
1023716	Slagghaug 2	5	2.5	1.1	28.8	
1023716	Slagghaug 3	1.9	1.9	0.5	3.8	
1023716	Slagghaug 4	1.3	1.3	0.5	1.8	
1023792	Slagghaug 1	4.1	2.5	0.9	19.3	
1023792	Slagghaug 2	3.9	2	0.9	14.7	
1023825	Slagghaug 1	4.7	2.2	0.8	17.3	

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
459.5	293.8	16.8		26.3		Unsure extent
459.5	293.8	39.9		62.4		
459.5	293.8	35.2		55.0		
459.5	293.8	9.3		14.5		
459.5	293.8	17.7		27.7		
459.5	293.8	4.3		6.7		
459.5	293.8	9.3		14.5		
459.5	293.8	12.5		19.6		
459.5	293.8	19.7		30.8		
459.5	293.8	14.3		22.3		
459.5	293.8	3.2		5.0		
459.5	293.8	4.3		6.8		
459.5	293.8	7.3		11.4		
459.5	293.8	5.6		8.8		
459.5	293.8	8.0		12.5		
459.5	293.8	27.3		42.7		
459.5	293.8	21.2		33.1		
459.5	293.8	10.6		16.6		
459.5	293.8	35.9		56.1		
459.5	293.8	1.2		2.0		
459.5	293.8	0.4		0.6		
459.5	293.8	0.7		1.2		
459.5	293.8	1.8		2.8		
459.5	293.8	0.5		0.8		
459.5	293.8	16.8		26.3		
459.5	293.8	12.5		19.6		
459.5	293.8	31.1		48.7		
459.5	293.8	33.8		52.9		
459.5	293.8	4.4		6.9		
459.5	293.8	2.1		3.3		
459.5	293.8	22.7		35.5		
459.5	293.8	17.3		27.0		
459.5	293.8	20.3		31.8		

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps (cont.)*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
1023859	Slagghaug 1	5.2	2.1	0.7	16.0	
1023859	Slagghaug 2	5.5	2.2	0.75	19.0	
1023886	Slagghaug 1	2.5	2.2	0.4	4.6	
1023969	Slagghaug 1	3.2	1.8	0.7	8.4	
1023981	Slagghaug 1	3	3	0.6	11.3	
1024253	Slagghaug 1	3	1.7	0.6	6.4	
1024478	Slagghaug 1	2.1	1.9	1	8.4	
1024478	Slagghaug 2	4.9	2.5	0.8	20.5	
1024478	Slagghaug 3	4.6	1.9	0.7	12.8	
1024478	Slagghaug 4	2.6	2.4	0.5	6.5	
1024607	Slagghaug 1	2.4	0.5	0.6	1.5	
1024917	Slagghaug 1	3.7	2.3	1	17.8	
1024917	Slagghaug 2	1.4	1	0.5	1.5	
1024965	Slagghaug 1	3.6	1.6	0.57	6.9	
1024965	Slagghaug 2	2.5	1.8	0.71	6.7	
1024965	Slagghaug 3	4.5	2.9	0.73	19.9	
1024965	Slagghaug 4	1.5	1.5	0.4	1.9	
1036553	Slagghaug 1	2.8	1.7	0.75	7.5	
1036553	Slagghaug 2	3.8	2	0.5	8.0	
1036553	Slagghaug 3	1.1	0.5	0.4	0.5	
1036553	Slagghaug 4	0.8	0.8	0.3	0.4	
1036613	Slagghaug 1	2.7	2.7	0.8	12.2	
1036613	Slagghaug 2	1.9	1.9	0.6	4.5	
1036633	Slagghaug 1	2.1	1.3	0.2	1.1	
1036812	Slagghaug 1	3.6	2.8	0.7	14.8	
1036812	Slagghaug 2	3.7	2	0.7	10.8	
1036812	Slagghaug 3	2.7	2.7	0.2	3.1	
1045015	Slagghaug 1	3.6	2.4	0.9	16.3	
1045015	Slagghaug 2	2.5	1.5	0.5	3.9	
1045015	Slagghaug 3	3	0.9	0.2	1.1	
1045015	Slagghaug 4	3.1	1	0.3	1.9	
1045127	Slagghaug 1	3	2.5	0.8	12.6	
1045127	Slagghaug 1, voll 1	2.5	2.5	0.4	5.2	
1045127	Slagghaug 1, voll 2	1.3	1.6	0.4	1.7	

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
459.5	293.8	18.8		29.4		
459.5	293.8	22.3		34.9		
459.5	293.8	5.4		8.5		
459.5	293.8	9.9		15.5		
459.5	293.8	13.3		20.8		
459.5	293.8	7.5		11.8		
459.5	293.8	9.8		15.4		
459.5	293.8	24.1		37.7		
459.5	293.8	15.0		23.5		
459.5	293.8	7.7		12.0		
459.5	293.8	1.8		2.8		
459.5	293.8	20.9		32.7		
459.5	293.8	1.7		2.7		
459.5	293.8	8.1		12.6		
459.5	293.8	7.9		12.3		
459.5	293.8	23.4		36.7		
459.5	293.8	2.2		3.5		
459.5	293.8	8.8		13.7		
459.5	293.8	9.3		14.6		
459.5	293.8	0.5		0.8		
459.5	293.8	0.5		0.7		
459.5	293.8	14.3		22.4		
459.5	293.8	5.3		8.3		
459.5	293.8	1.3		2.1		
459.5	293.8	17.4		27.1		
459.5	293.8	12.7		19.9		
459.5	293.8	3.6		5.6		
459.5	293.8	19.1		29.9		
459.5	293.8	4.6		7.2		
459.5	293.8	1.3		2.1		
459.5	293.8	2.3		3.6		
459.5	293.8	14.8		23.1		
459.5	293.8	6.1		9.6		
459.5	293.8	2.0		3.2		

APPENDIX III *Calculation of volume and estimation of weight of slag in slag heaps (cont.)*

Site	Slag heaps	A	B	C	Volume ellipsoid	Volume Total Station
1045127 <i>Rødsmoen</i>	Slagghaug 2	1.9	1.1	0.5	2.2	
R695	Slagghaug 1	4.2	3.1	0.86	23.4	25,9*
R695	Slagghaug 2	5	3.8	0.84	33.4	35,5*
R300	K1	2.2	1.7	0.4	3.1	11,5*
R300	K9	0.7	0.5	0.2	0.1	1,5*
R305	K1	4.5	3.2	0.7	21.1	Ikke beskrevet
R17a	K1*	3	2	0.75	9.4	Ikke beskrevet
R17a	K2*	1.5	1	0.3	0.9	Ikke beskrevet

Weight (kg) total 1/4 m3	Weight (kg) slag 1/4 m3	Weight of slag (ton) ellipsoid	Weight of slag (ton) Tot. Station	Weight total (ton) ellipsoid	Weight total (ton) Tot. Station	Comments
459.5	293.8	2.6		4.0		
		21,3**		29,3**		From report.*Volume in buckets/**calculated after weighing
		26,8**		37,5**		From report.*Volume in buckets/**calculated after weighing
459.5	293.8	2,8**		5.8	21.1	*Method not given/**calculated after weighing
459.5	293.8	0,1**		0.3	2.8	*Method not given/**calculated after weighing
459.5	293.8	9,7*		38.8		*calculated after weighing
459.5	293.8	10**		17.3		* Mesure after drawing/**calculated after weighing
459.5	293.8	1,2**		1.7		* Mesure after drawing/**calculated after weighing

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Index

Italics denote figures

- accelerator mass spectrometry *See* AMS
Adam of Bremen 313
Agder 24, 26, 45, 61
Agricola 78
Åker 288–290, 317, 347, 350
Åker Project 86, 87, 206
Alfareimr 283, 346
Älgarås 54
All, Jacob 314
Alvheim 312–313, 330
Åmot
 chronology of *jernvinna* in 325
 dating of *jernvinna* in 224, 244, 246, 247
 distribution of *jernvinna* in 192, 193, 210
 Evenstad tradition in 170
 hunting sites in 293
 recorded ancient monuments in 86, 87
 settlement in 279–283, 281, 291, 331,
 333–334 336
 in the written sources 306, 309, 315, 316
 See also Gråfjell; Rødsmo
AMS (accelerator mass spectrometry) 216,
 362
Amundsen, Hilde 291, 313, 330
Amundsen, Tina 280
Andersson, Hans 20
Ängersjö 79
Arvika 210
Åsamon 54
Åsnes 5, 84, 204, 285, 287, 293
Atndalen 187, 209
Aust-Agder 322
Azamon 54
Askeladden 11, 183, 186, 188, 190, 191, 193, 195,
 196, 197, 198, 200, 205, 206, 207, 215
Axamo 54, 55

Baglers 304, 305
Bakke, Leif 206
Bårdseng, Line 25, 88, 198, 206, 271–272, 289
Bårdsson, Skule 305
Barndon, Randi 23
Bartholin, Thomas 228

base slag 84, 98, 99
Bayes, Thomas 219
Bayesian approach 219–220, 230–242
Beitostølen 11, 63, 325
bellows 127–128
 water-driven 24, 27
Berg 301, 303, 317, 346
Berge, Ragnhild 73
Bergen 31
Berg-Hansen, Inger Marie 303
Bergslag 352, 353, 357–358, 359
Bergstøl, Jostein 276, 277, 291, 293,
 331, 334
birch 224, 225, 226, 353
Birch-legs 301, 305
Biringuccio, Vanoccio 70–71, 71
Birka 297, 298, 350
Bjørkvik, Halvard 307
Bjørn (governor) 299
Bjørnstad, Ragnar 59
blast furnaces 2, 39, 352, 353
Blindheim, Charlotte 297–298, 350
Bloch-Nakkerud, Tom 26, 150
Blom, Grethe Authen 304, 305, 309
bloomy sheds 60, 61, 138–142, 140, 147, 311,
 322
Bodø 56
bog ore 2, 25, 76–79, 77, 352
 consumption of 263, 265, 266–268, 268
 freedom to extract 310–312
 See also roasting places
boundaries in the Middle Ages 312–315
bowl furnace 48–49, 83, 84
Braathen, Helge 317, 318
Brandval 287
Braskreidfoss 284
Brøgger, A.W. 2, 42, 276, 332–333
Buchwald, Vagn Fabritius 78
Buhaugene 60
Bull, Jacob B. 184
Buskerud 63
Bykle 362
Bymarka 59, 73

- Carelli, Peter 30
- charcoal
- consumption of 257, 262, 264, 266–268, 268
 - volume of production 255–256
- charcoal pits 43, 67, 68, 69–71, 71
- in Europe 70–71
 - Falck-Muus on 85
 - location of 322
 - marking a claim on common land and 311
 - in Norway 71–76
 - chronology of 74–76
- charcoal pit sites 322
- Clarkson, Leslie A. 37, 39, 40
- clearance cairns 278, 283, 292
- commonality 310–312, 320
- Costin, Cathy L. 342–345
- Dagson, Ring 299
- Dalarnes 11
- Decree of 1358, Håkon VI Magnusson's 305–312 348, 354, 358–360
- Deisjøen 282
- dendrochronological dating 227–230, 229, 230
- Deset 170, 282, 348
- Deset Østseter 280, 281, 329, 335
- Diplomatarium Norvegicum* 301
- Dobres, Marcia 22
- Dokkfloy 19, 20, 25, 26, 32, 225, 321
- bloomery sheds 139, 140
 - charcoal pits 71, 150
 - furnaces 52, 53, 60, 63, 64, 67, 120
 - roasting places 171, 173
 - slag typology 95–96
 - volume of production 257, 269
- Dokkfloy type 188, 322, 324–325, 325
- Dokka Project 11, 161, 353
- Dørum, Knut 307, 317–318
- Edberg, Rolf 313
- Eg furnace 46, 50
- Egil 300
- Egilssoga* 300
- Eidsiva *thing* 310, 316
- Eidskog 5, 67, 287, 301
- Elffueddals kirikie* 302–303
- einvirke* 346
- Eldmyrene 167, 168, 180
- Elfardalr* 302
- Eltdalen 278
- Elverum
- charcoal pits in 88, 198, 223
 - chronology of *jernvinna* in 325, 330
 - dating of *jernvinna* in 224, 244–245, 247, 248
 - distribution of *jernvinna* in 9, 85, 88 194, 195, 196 210, 223
 - farming and *jernvinna* in 291
 - hunting sites in 293
 - settlement 276, 282, 283, 284, 331, 332, 336, 337
 - in the written sources 306, 313, 315
- Engerdal 330
- Englund, Lars-Erik 12, 50, 53, 54, 71, 77, 170, 172
- equestrian graves 317–318
- Erik King of the Swedes 300
- Eriksson, Magnus VII (king) 359
- Espelund, Arne
- on bog ore 352
 - on calculation of yield 253, 254
 - on dating of sites 185, 189, 198
 - on Falck-Muus 82
 - on furnaces 47, 48, 49–50, 58
 - on *jernvinna* as a term 2
 - and process of *jernvinna* 12
 - on roasting of ore 78
- Evenstad, Ole 47, 77, 78, 171, 173, 174
- Evenstad furnace 47, 50, 53, 55, 212, 257
- Evenstad tradition 2, 32, 53, 55, 74, 75, 88, 170, 184, 189, 257, 343
- Fairhair, Harald 297, 300
- Falck-Muus, Rolf 24, 77, 80–86, 339
- charcoal pits and 72, 74–75, 85
 - mapping of bloomery sites 80–82, 81, 88, 190, 193, 195, 196, 197, 198, 200, 204, 205, 213, 215
 - slag typology and 83–85, 96–98
- farm-names 277, 278, 279, 280, 281, 283, 285, 287, 290, 332
- Femunden 330
- Ferrum Noricum 49
- Fet 75
- field terraces 282, 283, 291, 292
- Fillefjell 48, 63, 69, 139, 321, 325

- Finehair, Harald 318
 Finnskogen 196
 Fischer, Gerhard 302
fjordunger 316
 Flåmsfjella mountains 73
Flatexjarbók 312, 313
 Florén, Andres 39
 Fornsök 211, 213, 215
 Fosvold, Anders 187, 301, 305, 306
Fra jernets saga 1
 free trade, right to 306–309
fullbonde 346
 furnaces
 blast furnaces 2, 39, 352, 353
 bowl furnace 48–49, 83, 84
 Dokkfloy furnace 52, 53, 60, 63–64, 64, 67, 120
 Eg furnace 46, 50
 Evenstad furnace 47, 50, 53, 55, 212, 257
 hybrids 337–339
 Linneröd furnace 53
 Mösstrand furnace 48, 52, 61, 67
 Østland furnace 24, 45, 49, 50, 64, 291, 331, 338, 340
 paired furnaces 54, 55, 56
 shaft furnaces 51–52
 slag pit furnaces 45–50, 46, 64
 slag tapping furnaces 46–54
 in Denmark 52–54
 in Europe 51–52
 of Gråfjell 118–128
 in Norway 65
 slag tapping shaft furnaces
 development and diffusion of 66–67, 338
 and charcoal pits 76
 in Norway 56–69, 66, 321
 distribution of 68–69
 in Sweden 54–56, 321
 Trøndelag furnace 45, 49, 50, 56
 Furnes 271
 Gåla 283
 Gausdal 19, 20, 26, 311, 322, 324, 325, 344, 361, 366
 Geirstad-elf, Olaf 299
 Glesmyr 285
 Glomma River 4, 68, 209–210, 312, 313, 326, 327
 Glomstad 306, 346
 Glørstad, Zanette Tsigaridas 298, 318
 Godstøylbekken 61, 62
 Gold-tooth, Halfdan 297, 298
 Gråfjell
 bloomey ironmaking sites in 88, 90, 90, 91, 98, 100, 101–117
 charcoal pits 91, 100, 148–161
 comparison with Rødsmoen 160–161
 distribution of 179–180, 320
 excavation of 149–156, 152, 153, 154, 155, 156
 phases of use of 153–154
 positioning of 179
 terminology for 150
 volume of charcoal production and 174, 180, 255–256, 256
 chronology of *jernvinna* in 15, 240, 240–246, 241, 242, 336–337
 components of ironmaking sites in 92–95, 94, 132–137, 133, 135
 dating of *jernvinna* in
 Bayesian approach 230, 232, 232–242
 dendrochronological dating 227–230, 229, 230, 231, 236–238, 238
 radiocarbon dating 223, 224, 230–240, 230, 231, 237
 distribution 175–181, 176, 177, 320
 of charcoal pits 179–180, 320
 and access to sources of ore 181, 320
 and access to woodland 179, 180, 181, 320
 of roasting places 180, 320
 economic models for *jernvinna* in 15, 182, 291
 excavation methodology in 92
 farms and *jernvinna* in 348
 furnaces in 118–129, 130
 isolation pits of 121–126, 122, 123, 124, 128, 147
 shafts of 118–121, 147
 slag typology in 95–98
 specialization in 344
 tapping channels 126
 tapping cones 126
 tapping plates 126
 tapping slag 95–96, 125–126
 hunting in 335

- organization of *jernvinna* in 132–147, 133, 135, 320
 300-type site classification 89, 89–90, 90, 130, 132, 147
 695-type site classification 89, 89–90, 90, 130, 132, 135, 137, 139, 141, 147
 bloomery sheds 138–142, 147
 comparison with Rødsmoen 146–147, 320
 variation in 133–137, 135, 139
 basic model 132–137, 135, 139, 147, 208, 320
 standard model 134–137, 135, 139, 208, 209, 320
 roasting places 161–175, 163, 165, 166, 167, 320
 construction of 171–173
 distribution/positioning of 180
 identification of 161–171, 165, 166, 167
 investigations of 162–171, 163, 167, 175
 terminology 161–162
 occupation of sites in 142–146, 324
 place-name evidence for *jernvinna* in 180
 political control over *jernvinna* in 182
 recorded ancient monuments of 7, 10, 87, 88
 settlement in 346
 terminology 92–95
 timber, use of in 226, 227
 topography, climate and vegetation of 6, 8
 unexcavated sites in 129–131
 organization of 137
 volume of production in 134, 136–137, 249–272, 351
 calculations of the volume of slag heaps 249–253, 257
 calculations of yield 253–269, 254, 257, 258–261, 262–265
 charcoal and 255–256, 256, 270
 consumption of 257, 262, 264, 266–268, 268
 consumption of raw materials and yield 266–269, 268
 iron 257–272, 258–261, 262–265
 through time 273–275, 273, 275
 ore, consumption of 263, 265, 266–268, 268
 period of use and 269–271, 270
 Grimsdalen 327
 Grue 5, 285, 286, 287, 332, 298, 347
 Grundset 88, 283, 336
 Grundsetmarka 330
 Gudbrandsdalen 187, 209, 321, 325
 Gullbekk, Svein H. 31, 356
 Haavaldsen, Per 60
 Håen 58
 Haglebu 62, 325
 Håkonsson, Håkon (king) 301, 305, 356
 Håkonsson, Magnus (king) 316
 Håkon the Good 300
 Halland 53
 Hallbekken 64, 65
 Hallingdalen 321, 322, 325
 Hamar
 dating of *jernvinna* in 224, 244–246, 245, 247, 248
 distribution of *jernvinna* in 204, 207, 210
 power of the Church and 315, 349–350
 taxation in 306
 as trading centre 288–290, 298, 317, 327, 347, 348, 350–351, 359
 Hamar Chronicle 288, 290
 Hammer, Paul B. 196
 Hardangervidda 32, 42, 60, 75
 Hardråde, Harald 289, 317
 Hardråde, Øystein 298
 Harsson, Margit 280, 281–282
 Harstad 75
 Hauge, T. Dannevig 77, 79, 85
 Hedemarken 4
 Church, power of in 349, 350
 distribution of *jernvinna* in 9, 88, 204, 206
 farming in 282, 296, 304, 330, 347
 hunting in 282, 293
 organization of bloomery sites in 208
 settlement in 276, 287–291, 331–332
 trading sites in *See* Hamar
 in the written sources 299, 303, 304
 Hedenstorp 54, 55
 Hedmark County
 ancient monuments in the outlying land of recorded by

major projects 86–88, 87

Hedmark tradition

chronology of 9–10, 243–248, 325,

336–340, 341, 349–360

dating of 203, 206, 216–237, 224

AMS (accelerator mass

spectrometry) 216, 217–218, 219

Bayesian approach 219–220, 230–242,
232

dendrochronological dating 227–230,
229, 230, 231, 236–238, 238

radiocarbon dating 216, 217–218, 219,
220–224, 224, 229, 230–240, 230, 231, 237

by region

South Østerdalen

Åmot 224, 244, 246, 247

Elverum 223, 224, 244–245, 247, 248

Rendalen 224, 244, 246, 247, 248

Stor-Elvdal 224, 244, 246, 247, 248

Trysil 223, 224, 244, 246, 247, 248

Solør 244, 246, 247, 248, 274

Åsnes and Grue 224

Eidskog 224

Våler 224, 244–245, 247, 248, 274

Värmland (Sweden) 224, 244–245,
247, 248

delimitation of 208–212, 325–326,

329–331, 349

settlement and 331

demise of 349–360

as distinct technological tradition 14–15,

208–209, 321–326, 323–324, 325, 361–362

distribution of 183–215, 215

Hedemarken 204–208

South Østerdalen 184–195

Åmot 192, 193

Elverum 194, 195, 210

Rendalen 184–185, 186, 194, 209,
214

Stor-Elvdal 185, 187, 188, 189, 194

Trysil 189, 190, 191, 192, 214, 223

Solør 196–204

Åsnes and Grue 196, 198, 199, 199
200, 201, 210

Kongsvinger and Eidskog 203,
205, 210, 212

Våler 196, 197, 198

Värmland (Sweden) 210, 211, 212, 214

Torsby 210, 212, 213, 214

economic models for 15, 182

origins of 339–340

settlement and 276–292, 286, 331–333

as a term, origins of 14

variations on 199, 201, 202, 208

volume of production 249–271, 271–275,

351

calculations of the volume of slag

heaps 249–253, 257

calculations of yield 253–269, 254,
258–261, 262–265

charcoal 255–256, 256, 270

consumption of 257, 262, 264,
266–268, 268

iron 257–271, 258–261, 262–265,
271–275

through time 273–275, 275

ore, consumption of 263, 265,
266–268, 268

period of use and 269–271, 270

wood species and 222–227, 226

written sources and 296–318, 349

boundaries 312–315

commonality 310–312

jernvinna 306–309

Håkon VI Magnusson's Decree of
1358 305–312, 348, 354, 358–360

Law of Royal Succession of

1273 304–305

local administration in the Middle

Ages 315–316

royal letters 301–304

saga literature 297–300, 313, 315, 316,
317, 329

See also Gråfjell

Heidegger 22

Heimskringla (Hkr) 297, 299, 314

Helgøya 290

Helle, Knut 30, 31

Hemmestad 73, 74

Hendalen 58–59, 183

Heradsbygda 283, 291

Heradsmarka 285

Hernes 283

herreder 316

Historia Norwegie (HN) 298, 299

Hof 84, 285, 287, 332

Hohle, Per 184

Holm, Ingunn 196, 283, 284, 328, 330, 359

- Holm, Olof 315
- Holmsen, Andreas 308, 309
- Hougen, Bjørn 26, 42
- Hovden
 charcoal pits in 74, 75, 150, 256
 chronology of *jernvinna* in 325, 366
 furnaces in 56, 62
 nature of *jernvinna* in 32, 61
 volume of iron production in 272, 362
- Huseby 285, 318
- Hveberg, Harald 284, 286, 287, 305, 317
- Hylestad doorway 127, 129
- Imsdalen 209, 327
- Indrelid, Svein 73
- Inge of the Swedes (king) 300
- Ingjald Ill-Ruler 297
- Ingold, Tim 22
- 'Iron Origin' project 366
- isolation pits 83, 94, 141, 339
- Jacobs, Marteen 23, 28
- Jakobsen, Sigmund 12, 255
- Jämtland 24, 45, 56, 170, 353
- Järnet och riksbildningen 1150–1350* 358
- Jels Skov 52
- Jensen, Jørgen Elsøe 363
- jernvinna*
 areas and boundaries of production 3–4, 9, 208–212, 325–326, 329–331, 349–349
 chronology of 9–10, 15, 322, 325, 336–340, 347, 349–360, 362
 Church, power of and 324–325, 349–350
 commonality and 310–312, 320
 in Denmark 52–54
 demand for iron and 362–364
 demise of 349–360
 economic context of 14, 15, 29–40, 270, 289, 319, 325, 327–329, 337, 342, 355–356
 economic models for 15, 31–40, 182, 291, 346–351
 cultural dualism 31–33, 291
 forest farm settlement 329–330, 346–347, 348
 gift-exchange system 33
 proto-industrialization 36–40, 345–346, 349–351
 redistributive system 33, 34, 346–349, 352
 specialization 34, 342–345
 exploitation of resources for 15, 24, 28, 224–227, 319, 352–353
 farming and 2, 9, 18–20, 26–28, 30, 336, 344, 346–348, 347
 economic models and 31–35, 342
 forest farm settlements 329–330, 346–348
 mountain farm theory 26, 332–333
 the outlying land and 18–19, 27
 royal farms 301, 303, 306–307, 317, 347
 future research directions 361–367
 hunting and 292–296, 334–336
 introduction of 44–45
 population growth and 354
 as a proto-industry 36–40, 345–346, 349–351
 regional variations in technology and organization 11, 21, 23–24, 321–322, 323–324
 research on 42–89, 361–367
 bog ore and roasting 76–79
 charcoal pits 69–76
 furnaces 45–69
 origins and use of the term 2
 role of in the development of the Norwegian kingdom 16, 342, 345, 347
 royal control over 304–312, 318, 325, 340, 342, 344, 347–350, 354
 settlement and 26–27, 276, 285, 289, 331, 337, 340, 346
 trade routes for 350, 363, 365
 transhumance and 327–329
 urbanization and 33, 363
 written sources and 11–12, 296–318, 349
- Jernskallen 180
- Johansen, Arne B. 31–32, 34, 42, 75, 331, 353
- Johansen, Herman Strøm 1, 3
- Johansen, Torkel 34
- JKS (*Jernvinna* together with charcoal Pits) tradition 19, 20, 69, 311, 321, 322, 344
- Jouttijärvi, Arne 53
- Karlsson, Catarina 363
- Kaupangkirken* 302–303
- Kaupangr* 189, 277, 301–304, 305, 308, 317, 350

- Kaupang research project 30
 Kiær, Christen C. 185
 Kilde 306
 Kind 71
 Kjelhusåsen 72
 Kjølsetra 282, 329
 Klarälvs River 6, 212, 214, 297, 312, 313, 326, 327, 330
 Kleiven, Ivar 71
 Knubblia 282, 329, 336
Kongveiene 302
 Kongshaug 285
 Kongshov 285
 Kongsvinger 5, 287
 Koppang 189, 301, 317, 348
 Koppangøya 301
 Koppangsjordet 302–303
 Koth, Halvdan 299
 Kloster, Robert 33
 Krag, Claus 297, 298, 310, 313, 342, 355, 356
 Kvitingøy, Peace and Treaty of 1208 304
- Langfjella 321, 338
 Larsen, Jan Henning 13, 72, 75, 353
 National Law 302
 Leksand 56
 Lemonnier, Pierre 22
 Lerdala 54
 Liabaret 60
 Lillehaugen 285
 Lillevold, Eyvind 278, 280
 Lima 55, 127, 189
 Linneröd furnace 53
 Lisætra 338
 Lista 84
 Ljørdalen 278
 Loftsgarden, Kjetil 26, 363–364
 Løsset 282, 348
 Løsset Nordseter 279, 291
 Løten
 dating of *jernvinna* in 224, 244–246, 245, 247, 248
 distribution of *jernvinna* in 206, 207, 210
 volume of production in 271
 Lunde, Harald 189, 190, 191, 195, 215, 292
 Lunden, Kåre 29–30, 35
- magnetometry 105, 162–164, 163
 Magnus Barefoot 300
 Magnus Law-mender 301, 304, 305, 356, 357
 Magnusson, Erik (king) 356
 Magnusson, Gert 24, 25, 170, 255, 353
 Magnusson, Håkon V (king) 303, 304, 306, 356
 Magnusson, Håkon VI (king) 305, 306, 358, 359
 See also Decree of 1358, Håkon VI
 Magnusson's
 Malmmyra 165, 167, 168, 180
 Markov, Andrei 220
 Markov Chain Monte Carlo Simulation See MCMC
 Martens, Irmelin
 on economic models for *jernvinna* 18, 19, 20, 26, 34
 on Møsstrand 25, 42, 48, 75, 170, 223, 362
 on Skotterud 204, 326
 on slag tapping shaft furnaces 59, 61
matterscape 23, 28
 Mauss, Marcel 22
 MCMC (Markov Chain Monte Carlo Simulation) 220, 235
 Melgårdsetra 282, 328, 335, 336
 Mendels, Franklin 37
 Messelt 283
 Millde, Ylva Stenqvist 28
mindscape 23, 28
 Mjøsa 330
 Møre og Romsdal 73
 Mortensson, Magne 285
 Moseng, Ole Georg 355, 356
 Møsstrand
 blooming sheds in 139
 charcoal pits in 75
 chronology of *jernvinna* in 325
 economic model for *jernvinna* 19, 34
 furnaces 48, 52, 61, 67
 location of sites in 24, 25
 studies of *jernvinna* and 42, 61
 radiocarbon dating in 223
 roasting of ore in 170
 trade routes and 363
 volume of production in 362
 Møsvatn, Lake 19, 48, 61, 69, 321
 Møsvatn tradition 69, 321, 322
 Munch, P.A. 314
 Myhre, Bjørn 26

- Næs, Sigurd 302
- Narmo, Lars Erik
- on charcoal pits 311
 - on development of the Dokkfloy type 324–325
 - on economic models for *jernvinna* 19, 20, 24, 26, 32–33
 - on furnaces 48, 50, 63, 65
 - on Hedmark tradition 13, 14
 - on hunting and *jernvinna* 334, 336
 - on organization of *jernvinna* 68–69, 71
 - on regional variation 320, 322
 - on roasting places 161, 171, 172, 174
 - on settlement 280–281
 - on site organization 137
 - on slag typology 95
 - on volume of iron production 269, 271, 361
- Nes 333–334, 346
- Neset 60
- Nidaros 73, 301, 302, 306, 315
- Nielsen, Niels 53
- Nihlén, John 53
- NIKU (Norwegian Institute for Cultural Heritage Research) 10, 87, 90, 92, 117, 131, 179, 251
- Nordre Valldalseter 59
- Noreen, Erik 314
- Norra Finnskoga 224 212
- Numedal 79
- Odda 73
- Ogilvie, Sheilagh C. 345
- Øiensjøfoss ironworks 2
- Olafsen, Olaf 196
- Olafsson, Ingjald 298
- Olaf the Saint 299, 300, 317
- old wood effect 224
- Oppen, Captain 173
- Oppland County 11, 63, 187
- Opplandene 184, 288, 289, 297, 299, 304, 305, 307, 317, 318
- ore *See bog ore*
- Örsås 54
- ‘Osmond’ iron 357
- Østerdalen
- distribution of *jernvinna* in 9, 184–195
 - Evenstad tradition in 32, 47
 - geography of 4, 6
 - Håkon VI Magnusson’s Decree of 1358 and 305–308, 348, 354, 358–360
 - local administration of in Middle Ages 315, 317
 - proto-industrialized *jernvinna* in 346–351
 - roasting places in 187
 - royal lordship of 317
 - settlement in 276, 290, 291, 299, 331–334, 337
 - transhumance in 327–329
 - in the written sources 299, 301, 304, 305, 307–310
 - See also* Åmot, Elverum, Rendalen, Stor-Elvdal, Trysil
- Østerdalen Barracks 86
- Østland furnaces 24, 45, 49, 50, 64, 291, 331, 338, 340
- Øverdalssetra 187
- Øvstedalen 60
- Øyer 48, 324
- Øysteinsson, Hogni 299
- Øystre Slidre 362
- outlying land 16–20
- as a resource zone 13–14, 15, 16–20
- Outlying Surveys 86, 87, 183, 184, 196, 206, 272
- Pedersen, Unn 13, 304
- Persson, Thomas 74
- Pettersson, Tåpp John-Erik 77, 78, 173
- Pfaffenberger, Bryan 22
- picks 138, 138
- Pilø, Lars 288
- pine 224, 225, 226, 227, 228, 234, 353
- pit slag 98
- place-names
- as evidence for *jernvinna* 180
 - as evidence of settlement 281–282, 283, 287, 288, 290, 348
 - See also* farm-names
- Pleiner, Radomir 51, 52, 67, 71
- Polanyi, Karl 29, 31
- post-reduction slag 98
- powerscape 23, 28
- proto-industrialization 36–40, 345–346, 349–351

- radiocarbon dating
 Gråfjell 230–240, 230, 231, 237
 Hedmark tradition 216, 217–218, 219,
 220–224, 224, 229, 230–240, 230, 231, 237,
 243–248
 Ramsey, Bronk 220
 Raud (chieftain) 299, 329
Raudasmiðja 310
 Raudfjellet 180
 Rauland 325, 363
Regionfelt Østlandet See Gråfjell
 Rena 332, 348
 Rena River 279
 Rendalen
 dating of *jernvinna* in 224, 244, 246, 247,
 248
 distribution of *jernvinna* in 184–185,
 186, 194, 209, 214
 hunting in 292, 303
 settlement in 278, 290, 331, 332
 volume of production in 272
 Rennmyra 285
 Ribbungs 305
 Ringebu 187
 Ringsaker
 dating of *jernvinna* in 224, 244–246, 245,
 247, 248
 distribution of *jernvinna* in 204, 206,
 207, 210
 hunting in 293
 Risbergmarka 196, 198, 201
 Risbøl, Ole 348
 roasting places 94, 161–175, 163, 165, 166, 167,
 180, 320
 rock ore 78
 Rød Mellem (farm) 329
 Rødseter 282, 330, 335
 Rødsetervolla 329
 Rødsetra 110–111, 328, 329, 335, 348
 Rødsmoen
 bloomery sheds in 139, 140, 140, 141
 calculations of yield in 254, 257
 charcoal pits in 150, 153, 160
 furnaces in 47, 64, 65, 66, 67
 furnace shafts in 118
 hunting in 293, 334–335
 R695 140, 140, 141, 249, 251, 252, 271
 radiocarbon dates for 223, 224, 242–243,
 244
 roasting places in 162, 171, 173
 settlement in 282, 333–335
 site types in 89, 132, 133, 135, 137, 146–147
 slag 125
 surveys 10, 14, 86, 87, 87
 volume of production 271
 Rogaland County 60, 73, 84
 Rolfsen, Perry 61, 362
 Romerike 307, 317, 318, 332
 Rosenquist, Anna M. 12
 royal letters and *jernvinna* 301–304
 Rydén, Göran 39
 Rygh, Oluf 302

 Saami culture 278
 saga literature and the Hedmark
 tradition 297–300, 313, 315, 316, 317, 329
 Sæther, Tor 288–289, 290
 Schlumbohm, Jürgen 38, 39
 Schøning, Gerhard 204
 Schultze, Lars T. 174
 Serning, Inga 350
 Setersdal heaths 56
 shafts 94, 118–120
 shielings 26–27, 282–283, 291, 292, 327–329,
 335–336, 346
 Sigurðsson, Jón Viðar 30, 310, 355, 359
 Simonsson, Phillippus 304–305
 Sindbæk, Søren M. 301
 Skåne 53
 Skara 54
 Skiringsal 298, 304, 350, 356
 Skotterud 204, 326
 Skre, Dagfinn 30, 297, 317, 318
 Skrubbaldalen 60, 335
 slag beads 96
 slag, tapping 49, 95–96
 slag tapping furnaces 46–54
 in Denmark 52–54
 in Europe 51–52
 of Gråfjell 118–128
 in Norway 65
 slag tapping shaft furnaces
 development and diffusion of 66–67,
 338
 and charcoal pits 76
 in Norway 56–69, 66, 321
 distribution of 68–69
 in Sweden 54–56, 321

- slag typology 83–85, 95–98, 125–127
slag heaps 94, 250
 and volume of production 131–132, 136–137, 249–253, 251, 252
slag waste 94
Småland 54
Smekalov, Sergej 164
Smekalova, Tatyana 163, 164
Smith, Axel C. 179
Smith, E.A. 1
Södra Finnskoga 135, 212, 213
Søgårdsvollen 335
Solem, Jon 308, 310, 354
Sølendalen 277
Solli, Britt 73
Solli 187, 188, 209
Solør
 chronology of *jernvinna* in 325, 337, 339, 340, 347
 dating of *jernvinna* in 244, 246, 247, 248, 274
 distribution of *jernvinna* in 196–204
 hunting in 293
 local administration of in Middle Ages 315, 316
 royal lordship of 317
 in the saga literature 297, 298, 299, 300
 settlement in 276, 283–287, 290, 332, 337
 See also Åsnes; Eidskog; Grue; Kongsvinger; Våler
Solveig (daughter of King Halfdan Gold-tooth) 297
Solvi, King 298
Solvi the Old 297
Sørensen, Steinar 277–278, 279
spruce 224, 225, 226, 227, 228
Stange 293
Stavlia 282, 334
Stavsjøen 59
Steinnes, Asgaut 306, 313
Stene, Kathrine 110–111, 335
Stenvik, Lars 26, 34, 58
Stilborg, Ole 120
Storbekken 58
Stor-Elvdal
 chronology of *jernvinna* in 309
 dating of *jernvinna* in 224, 244, 246, 247, 248
 distribution of *jernvinna* in 9, 88, 185, 187, 188, 189, 194
 hunting in 291, 292
 settlement in 88, 276–278, 331, 336, 347
 in written sources 301, 302, 305
Storm, Gustav 313
Strömberg, Bo 27, 38–40, 53–54, 330–331
Styggdalsseter 282
substantivist theory 29
Sudndalslia 62–63, 321
Sudndalen 69
Sundt, Eilert 196
Surnadal 60
Svartholtet 88
Svensson, Eva 18–19, 20, 212, 214, 272
Sverre, King 305
Sysendalen valley 73
systemann 316
Tæbring 53, 125
tapping channels 95, 126
tapping cones 84, 96, 96–97, 126
tapping plates 83, 97, 126
tapping slag 49, 95–97, 96, 97, 125–126
Tarald 301
Tatara technology 125
taxation 306–309, 315
Telemark 322
technological boundaries 20–21, 23
technology, as a concept 21–23
temperature, importance of 2–3
Thorleifsen, Magne 191
Thuesen, Arthur 82
time-width 44, 107, 224, 227, 228, 229, 234, 240, 242, 362
Toflodslandet 312
Torge 350
Torsby
 dating of *jernvinna* in 224, 244–245, 247, 248
 distribution of *jernvinna* in 210, 212, 213, 214
 volume of production in 272
trade routes 350, 363, 365
Tranemo 54, 55, 56, 174
transhumance 327–329
Transtrand 55
Tree-feller, Olaf 297, 298, 299, 300, 312, 313, 330, 332

- Trøndelag
 charcoal pits in 73, 74
 economic models for *jernvinna* in 33, 34, 351
 exploitation of natural resources in 225
 furnaces in 45, 49, 50, 56, 58–59
 location of bloomery sites in 24, 25, 26, taxation in 307
- Trysil
 charcoal pits in 72, 223
 dating of *jernvinna* in 223, 224, 244, 246, 247, 248
 distribution of *jernvinna* in 189, 190, 191, 192, 214
 hunting in 292–293
 settlement in 278–279
 trading sites and 350
- Trysil River 214, 278, 313, 326, 327, 330
- Tvååker Project 53
- Tveiten, Ole 60, 62, 69, 308, 310–311, 321, 338, 354
- Tuyère 127
- Tyinkrysset 11
- Tynset 306
- Tyskeberget 82, 82, 339
- utmark* See outlying land
- Utmarksregistreringer i Hedmark* See Outlying Surveys
- Valdres 19, 69, 311, 321, 322, 362
- Våler
 chronology of *jernvinna* in 325
 dating of *jernvinna* in 224, 244–245, 247, 248, 274
 distribution of *jernvinna* in 196, 197, 198
 hunting in 293
 settlement in 283–285, 332
- Vänern 300, 313
- Vang 206, 271
- Värmland
 chronology of *jernvinna* in 325, 337
 dating of *jernvinna* in 244–245, 247, 248
 distribution of *jernvinna* in 210, 211, 212–214
 furnaces in 54, 56
 hunting in 294
 national boundaries and 299, 300, 312, 313, 314, 315, 326, 327, 330
 in the saga literature 297, 298, 299–301
 settlement in 332
 volume of iron production in 272
- Västerdalarne 54
- Västergötland 54
- Västgöta-law 314
- Västres Tandö 55, 56, 327
- Vättlösa 54
- Vattrup 52
- Vedby 53
- Vefsn County 72, 76
- Veøy 73, 76
- Vestby Søndre(farm) 278
- Vestfold 297, 299, 304
- Vestre Æra 329
- Vestre Jernskallia 180
- Vestvågøy 72, 75
- Vigrestad, Øystein 304–305
- Viken 298, 301, 305, 307
- Vinger 287
- Vittsjö 53
- Voss, Olfert 53
- Werlauf, Erich Christian 314
- whetstones 144, 365
- Whiteleg, Halfdan 298
- woodland, as a resource 174, 175, 179, 327, 352–353
- wood species and *jernvinna* 222–227, 226
- Ynglinge saga* (*Y.saga*) 297, 298, 299
- Ynglingetal* (*Y.t.*) 297
- Zetterberg, Pentti 227, 228